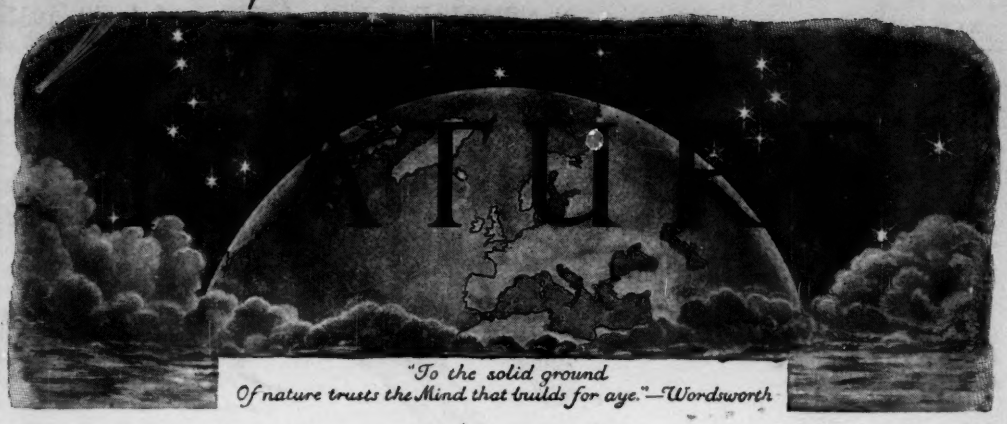


VOL. 180, No. 4576 SATURDAY, JULY 13, 1957 2s. 6d.

PERIODICAL READING ROOM

The key to your circuit problems

"METROSIL"
is a non-ohmic resistance having the characteristic CURRENT ∝ (VOLTAGE)$^{\beta}$.

Some proved uses are in:
SURGE SUPPRESSION · LIGHTNING ARRESTERS · VOLTAGE REGULATION · FIELD CONTROL · SPARK SUPPRESSION · RADIO CIRCUIT PROTECTION

Send for leaflet
NO. 220/1-1

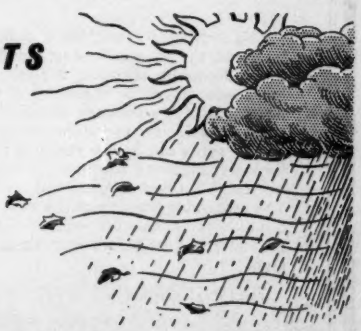
METROPOLITAN-VICKERS ELECTRICAL Co. Ltd., Manchester, 17
An A.E.I. Company NM/601

H. TINSLEY & CO. LTD.
SCIENTIFIC INSTRUMENT MANUFACTURERS

Strain-measuring equipment
Voltage Stabilizers
A.C. Potentiometers
Iron Testing equipment including Automatic Hysteresis loop tracer, etc.

WERNDEE HALL, SOUTH NORWOOD, LONDON, S.E.25
TELEPHONE: ADDISCOMBE 6046

METEOROLOGICAL INSTRUMENTS



You will find the accuracy and robust construction you need in all meteorological instruments by Negretti & Zambra.
Great sensitivity and long life are built-in qualities of every instrument we make.
Send for publication M/4, post free on request

NEGRETTI & ZAMBRA
122 REGENT STREET · LONDON W1
Telegrams: Negretti, Piccy, London. REGent 3406
BRANCHES: BIRMINGHAM · CARDIFF · GLASGOW
LEEDS · MANCHESTER · NOTTINGHAM
TECHNICAL SERVICE AVAILABLE IN MOST COUNTRIES

ANEMOMETERS · BAROMETERS
HYGROMETERS · RAIN GAUGES
THERMOMETERS · SUNSHINE RECORDERS, etc.

Manufacturers of instruments for the indication, recording and controlling of temperature, pressure, liquid level, volume, specific gravity, humidity etc., aircraft instruments.

An
UNFAILING
Source of
Vacuum by the
SIMPLEST
Most
ECONOMICAL
Method possible

. . . and no other equipment is necessary—just a "SPEEDIVAC" WATER JET PUMP connected to an ordinary water tap and a vacuum of 12-15 mm. Hg is available. Produced to precision vacuum engineering standards and incorporating unique high-speed jets and non-return valves, "SPEEDIVAC" pumps are often imitated in design but never approached in performance.

★ Available in all-metal, 22/- ★ Plastic, 10/6

For better vacuum service . . .

EDWARDS HIGH VACUUM LTD

MANOR ROYAL · CRAWLEY · SUSSEX CRAWLEY 1500 (10 LINES) EDCOHIVAC CRAWLEY

BRANCHES GLASGOW TORONTO & MILAN
AGENTS THROUGHOUT THE WORLD

CASELLA LONDON

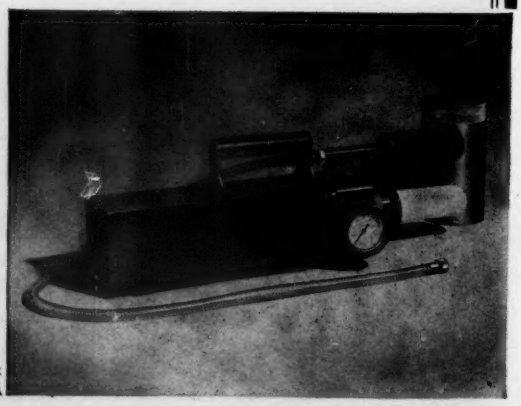
A NEW INSTRUMENT FOR SAMPLING AIRBORNE DUST—

THE HEXHLET

This instrument enables a bulk sample of the 'respirable' fraction of a dust cloud to be collected for subsequent chemical analysis. It employs a horizontal elutriator consisting of a number of flat horizontal ducts through which air is drawn at a constant velocity, such that particles above about 7μ will settle out before reaching the end. The air flow is maintained constant by means of a 'critical orifice'. Suction is provided by an air ejector. The respirable fraction of the dust is collected in a Soxhlet filter thimble which will hold up to 2 grammes of dust before its resistance becomes too high.

THE INSTRUMENT IS NOW IN PRODUCTION

Write for Leaflet No. 865



C. F. CASELLA & Co. Ltd.
REGENT HOUSE, FITZROY SQUARE
LONDON, W.1
Telephone : ★EUSton 3944
Member Scientific Instrument Manufacturers' Association of Great Britain

NATURE

No. 4576 SATURDAY, JULY 13, 1957 Vol. 180

CONTENTS

Page

Teachers in Technical Colleges 53

Terminology in Physics and Electronics. By Dr. J. R. Tillman 55
Swedish Exploration in South Africa. By Prof. O. Lowenstein, F.R.S. 56
Oxine and its Derivatives. By Dr. G. M. Bennett, F.R.S. 57
Thermochemistry. By Dr. E. F. G. Herington 57
Differential Equations. By Dr. L. S. Goddard 58

The Jodrell Bank Radio Telescope. By Prof. A. C. B. Lovell, O.B.E., F.R.S. 60
The Non-Toxicity of Maleic Hydrazide for Mammalian Tissues. By Dr. J. M. Barnes, Dr. P. N. Magee, Prof. E. Boyland, Prof. A. Haddow, Prof. R. D. Passey, Prof. W. S. Bullough, Dr. C. N. D. Cruickshank, Dr. M. H. Salaman and Prof. R. T. Williams 62
Atomic Energy and its Biological Implications. By Sir John Cockcroft, O.M., K.C.B., C.B.E., F.R.S. 64

Obituaries :
Dr. Josephine Macalister Brew, C.B.E. By Sir John Wolfenden, C.B.E. 68
Dr. J. E. Hamilton, I.S.O. By Dr. L. Harrison Matthews, F.R.S. 68
Dr. J. F. Allan 68

News and Views 69

Initiation and Growth of Explosion in Solids. By Dr. A. D. Yoffe 73
Recent Advances in High Polymer Physics. By Dr. A. S. Lodge 75
Tree Physiology. By Dr. P. F. Wareing 77
New Nature Reserves in Britain 78
Carnegie Institution of Washington 79
Chemical Research Laboratory 80
Autonomous Action of Lethal Mutations induced by the Germ Cells of *Drosophila melanogaster* by 2-Chloroethyl Methanesulphonate. By C. E. Purdom 81
Role of Cations in Phage Adsorption to Sensitive Bacteria. By J. Beumer, J. Dirkx and M. P. Beumer-Jochmans . . 83
Localization of Radioactive and Stable Heavy Nuclides in Ocean Sediments. By Dr. G. Arrhenius, M. N. Bramlette and Dr. E. Picciotto 85

Letters to the Editors :

Electron Micrographs of Cross-Sections of Protein Monolayers.—E. H. Mercer 87
Ion Cyclotron Resonance.—Dr. R. F. Saxe 87
Excited Levels in Arsenic-75 produced by Radiative Capture of Protons by Germanium-74.—D. R. Chick and S. E. Hunt 88
X-Ray Radiation Hazard using Vacuum Deposition Plant.—L. Holland 89
Thallium-activated Sodium Chloride Recrystallization Phosphors.—Z. Morlin 89
Reaction of Nitrates with Liquid Sulphur Dioxide.—Dr. K. J. Ivin 90
Interference in Soil Phosphorus Analyses by Snail Shells.—P. M. McDonnell 90
Reaction of Bromine with Uracils.—Dr. Shih Yi Wang . 91
A Modified Nagler Medium.—A. T. Willis and G. Hobbs 92
Proteolysis of Collagen.—G. H. Green 93
Size and Shape of Cartilage Mucoprotein.—Dr. Giorgio Bernardi 93
Ion Permeability of the Plasmalemma of the Plant Cell.—N. A. Walker 94
Efficiency of Ion Transport in Biological Systems.—Dr. J. F. Sutcliffe and D. P. Hackett 95
Fungistasis as a Factor in the Rhizosphere Phenomenon.—R. M. Jackson 96
Ovicidal Action of Organo-phosphorus Insecticides.—K. N. Mehrotra and B. N. Smallman 97
Hens with Bilateral Oviducts.—Prof. Walter Morgan and William Kohlmeyer 98
Parasitism in Relation to the Pituitary of *Ophicephalus punctatus* and *Barbus stigma*.—A. G. Sathyanesan . 98
Classification of Wool Follicles in Sheep.—Dr. A. B. Wildman 99
Vernal Sloughing of Sludge Deposits in a Sewage Effluent Channel.—R. W. Edwards 100

CHAPMAN & HALL

Ready 24 July

THE SPECTROSCOPY OF FLAMES

by

A. G. GAYDON, D.SC., F.R.S.

(Warren Research Fellow of the Royal Society)

10" × 6¼" 279 *pages* *Illustrated* 50*s. net*

This new book, although it covers slightly different ground, aims at replacing Dr. Gaydon's previous book *Spectroscopy and Combustion Theory*. The author and his colleagues at Imperial College have been associated with the development of a number of recent experimental techniques for controlling flames or for exciting flametype spectra in special sources. These techniques and the results obtained by them are given special emphasis in the work.

GAS CHROMATOGRAPHY

by

A. I. M. KEULEMANS

(Research Chemist, Koninklijke/Shell Laboratorium, Amsterdam)

A new Reinhold Book 9¼" × 6" 217 *pages* *Illustrated* 60*s. net*

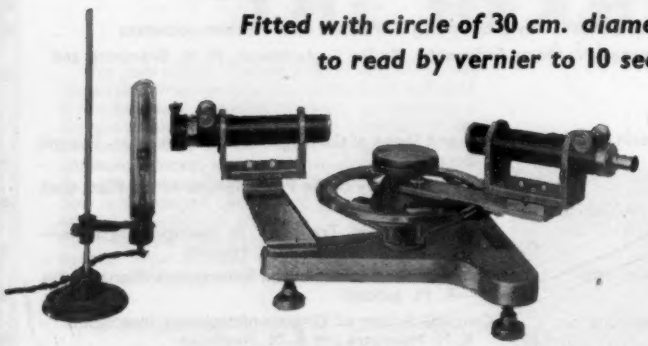
A concise, practical manual and an authentic, up-to-date summary of the field of gas chromatography written by chemists who have for many years been among the most active investigators of all varieties of chromatography.

37 ESSEX STREET, LONDON, W.C.2

PRECISION BS INSTRUMENTS

Spectrometer No. 3

Fitted with circle of 30 cm. diameter divided to read by vernier to 10 seconds



PRISM TABLE rotates and is fitted with levelling screws

TELESCOPE AND COLLIMATOR have centring adjustment

EYEPIECE is of 25 mm. separation

Our technical staff are always available to give help or advice on any of our instruments or their uses.

Bellingham & Stanley Ltd.

DEPT. N, 71 HORNSEY RISE, LONDON, N.19

PHONE: ARCHWAY 2270

TEACHERS IN TECHNICAL COLLEGES

IT is now recognized that, in spite of some definite shortcomings, the White Paper on Technical Education published in February 1956 is something of a landmark. It did not, perhaps, distinguish sufficiently clearly between the functions of the technical colleges and the colleges of technology and the university departments of technology, nor did it attempt to assess the quantitative demand for technicians and craftsmen. However, it recognized clearly enough that Britain's needs would only be met if the understanding and support of parents as well as of industry could be secured, and also that buildings were only a part of the problem. A critical factor was the supply of teachers.

This subject was not considered in any detail in the White Paper, which stated that there were at that time some 11,000 full-time and 46,000 part-time teachers in technical colleges, about 9,500 of whom were school teachers who teach in the technical colleges in the evening; and it merely observed that many more teachers would be required to enable the annual output of students from advanced courses to be increased to 15,000 in 1960, and that of students attending part-time day courses during working hours from 335,000 to double that figure. It was recognized that the quality of the teaching staff would be just as important as numbers if the technical colleges were to contribute appropriately to the output of scientists and technologists and to the supply of technicians and craftsmen required by industry and commerce. In June 1950, however, Sir David Eccles, then Minister of Education, appointed a committee, under the chairmanship of Dr. Willis Jackson, to consider, in the light of the White Paper, the supply and training of full-time and part-time teachers for technical colleges, and this committee has now reported*.

Apart from the estimates as to the demand for teachers, the report contains little that is fresh. There are some novel recommendations, but essentially no new suggestions regarding sources of supply. Nevertheless, the report is sane and constructive, and throws a welcome emphasis on factors that are frequently neglected. The problems to be solved are clearly displayed; just as the shortage is the resultant of neglect in many different directions, so is the adequate supply of Britain's needs in technical manpower shown to depend on a united effort in which the Government, the local authorities, the universities, industry and the general public as well as the colleges themselves, teachers and the schools have their own parts to play.

As to the present staffing of the technical colleges, there are no Ministry statistics later than those for March 1955, when some 10,000 full-time and 44,000 part-time teachers were in establishments of further education having day-work, other than art establishments. The colleges themselves reported 11,455 full-time teachers (including some in art establishments engaged on technical work) and 38,959 part-time (omitting some teachers engaged on evening-work only) in the 1955–56 session. These latter figures were used by the Committee in arriving at its estimate that the number of teachers would require to be increased by about 8,500 by 1960–61 to carry the additional load involved in the White Paper's proposals, or about 1,700 annually, compared with the annual average of 1,100 for 1952–55. This calculation, moreover, is based on the present average number of teaching hours per teacher, and even if the expansion in student numbers proceeds more slowly than the colleges anticipate, this rate of expansion is desirable to permit some reduction in average teaching hours, which for some individuals the Committee regards as excessive. This annual increment is to be made up of about 1,430 full-time teachers and about 1,600 part-time teachers, and should suffice to carry the expected increase of nearly 50 per cent in the teaching load and meet the desire of the colleges to see the full-time teachers in 1960–61 carrying 71 per cent of the total teaching load in place of the present 65 per cent. This aim is generally supported by the Committee and is regarded as a necessary consequence of the expansion in day-release work. Moreover, it provides a permanent and stabilizing factor in colleges, giving an element of continuity which is particularly necessary when most of the student body is made up of part-time students. Further, it simplifies administration and organization, while full-time staff can devote time to the general welfare and social life of the college as a whole in a way that could not reasonably be expected from a large body of part-time teachers. The programme of work of a full-time teacher can also be framed so as to give him adequate time for careful preparation, marking, devising and setting up experiments and visual aids, and for taking a personal interest in the progress and careers of his students.

These are all major factors in the relation between staff and student, and are particularly important with part-time students. Furthermore, while even with this swing to full-time teaching the colleges will require an extra 8,000 part-time teachers by 1960–61, it is possible the colleges may have under-estimated the relief which part-time teachers can give to the full-time teachers; and while there are other reasons for hoping that industry will be able and willing to release staff at all levels for part-time teaching, it is wise to assume that this average annual increase of 1,600 part-time teachers during the next five years is a minimum one. There is the further problem, which Dr. Willis Jackson stressed in explaining the report at the Conference organized by the Federation of British Industries on May 15, that acute difficulty is likely to be encountered in securing an adequate supply of well-qualified teachers of science or technology for professional courses at intermediate and advanced level. For these courses an increase is

* Ministry of Education. The Supply and Training of Teachers for Technical Colleges: Report of a Special Committee appointed by the Minister of Education in September, 1956. Pp. xiv+68. (London: H.M. Stationery Office, 1957.) 4s. net.

required of about 1,250 in the number of science graduates and of about 1,350 in the number of technology graduates. Disregarding staff wastage, which is at present unduly high, these figures mean raising the average net increase in the number of mathematics and science graduates in service from about 200 to 250 and of technology graduates from 90 to 265.

Before considering what Dr. Willis Jackson described as the kernel of the report—the provisions for meeting the needs, and especially those making teaching in technical colleges as attractive as it should be—it should be noted that the colleges since the War have sometimes had great difficulty in recruiting sufficient staff, particularly in the fields of science and technology. These difficulties in recruitment have been in the quality as well as in the number of applicants, and they have led to the overloading of the full-time staff in terms of class-contact hours, to the undesirable use of part-time staff through inability to fill full-time posts, and to an excessive turnover of staff since promotion at other colleges is so easy to secure. There is also risk of lowering the standard of the profession, since staff of inadequate quality is sometimes appointed.

The future requirements of British technical colleges for teachers are thus large, and in the main they are for specialists, who must be attracted from other forms of employment in which they are in equally great demand. The Committee can suggest no substantial fresh source of supply, and recognizes that no large source of persons suitable for full-time appointments remains untouched. The additional teachers must come, in the main, as they have always done, from industry, from university teaching and from the schools; but although the Committee believes that some married women with qualifications in mathematics and science may prefer teaching in technical colleges to teaching in schools, it does not appear to look to women teachers, either full-time or part-time, as likely to provide any considerable source of supply.

One possible field of recruitment to which the Committee directs attention is the Armed Services, where there are now many people with accepted qualifications as a result of Service training. Since the requirements of the Services are likely to be reduced, the Committee makes the reasonable suggestion that positive measures should be taken to ensure that all technically qualified regular officers and Service-men are made fully aware of the opportunities in technical education, and it believes that much more could be done to supply the Forces Resettlement Service with up-to-date information about technical education and the great need for teachers. Equally sound are the suggestions, in accordance with the tendency for the creativeness of a research worker to diminish in middle age or later, that measures should be taken to ensure that these opportunities and needs in technical education should also be brought effectively to the notice of such workers in the Scientific Civil Service, the research associations and in industry. Apart from this factor, the changing interests and growth in experience of such research workers might well lead a certain proportion to take up technical teaching and bring to the colleges an outlook and an expert knowledge of special subjects which would be of great value.

Such measures illustrate one factor on which the success of the recruitment campaign, as the Committee sees it, will depend: a willingness to develop unconventional sources of recruitment. That factor is also illustrated by the observations on the use of part-time teachers not only from industry but also from Government establishments and elsewhere, particularly in the remarks as to special inducements. There is sound sense in the observation that, to attract such staff of the calibre required, inducements should not be thought of as primarily financial: staff are much more likely to be attracted by offering them a special status in college life, with a title such as 'special lecturer' or occasionally 'special reader'.

Here, however, the other two factors which the Committee stresses as conditioning success are involved: establishment of a closer partnership between the colleges and industry; and a determined effort on the part of all concerned to raise the status of technical teachers and the attractiveness of their calling. It is recognized that the assistance and support of governing bodies and the local education authorities concerned will also be required, and on this point of co-operation the report is forthright. The Federation of British Industries in its "Handbook on Industry and the Technical Colleges" issued last autumn was content to remark that industry could help the colleges by assisting the recruitment of part-time lecturers of the right type. Dr. Willis Jackson and his colleagues are convinced that there is still too marked a tendency for educational institutions and industry to be regarded, and to regard themselves, as separate and distinct rather than as intimately associated partners in a joint enterprise. The real problem is being ignored so long as the possible gain by a technical college of a highly qualified and experienced recruit from industry is regarded as a loss to be resisted. For some time to come, industry must be prepared to encourage and assist the transfer to full-time teaching work of experienced staff members it can ill afford to lose, as the only means of ensuring a much augmented supply of junior recruits of high quality.

The value of a much greater interchange of staff and ideas in furthering the wide publicity required in order to attract sufficient additional teachers is obvious. Evidence submitted to the Committee suggests that at present more than a quarter of the new staff recruited by the technical colleges are teachers transferring from full-time service in schools. Disregarding the effect of such transfer on the schools, and disregarding the possibility that it may in due course be affected by the activities of the Industrial Fund for the Advancement of Scientific Education in Schools, this source of supply does not meet the vital need for more graduate technologists. To increase the supply of teachers of technology from 150 to 360 a year will require a great effort from all concerned.

To secure the desired co-operation from industry and government departments as well as from the Ministry of Education, the local education authorities and the technical colleges, every effort must be made to arrange the most effective deployment of staff. Nor is this simply a matter affecting teaching staff alone—particularly the more highly qualified members—and the rationalization of courses. It implies avoiding waste of special skill and knowledge on duties which do not require it, and seeing that highly qualified members of staff do not waste their time on routine clerical work or maintenance and repair of equipment but are provided with adequate clerical and laboratory assistance. This applies also in industry and elsewhere if the full potentialities of the additional sources of supply suggested in the report are to be realized.

More than the elimination of waste of skilled effort is involved here. Such conditions are an important factor in attracting staff of high quality, and the Committee comments wisely in the same connexion on the importance of allowing the mature entrant from the Armed Services, from industry or from research institutions full credit for his previous experience in determining his salary. The difficulties in regard to pension schemes are fully recognized, but the Committee considers that industrial pension schemes should provide, whenever possible, for a paid-up policy to be granted to those who resign to take up teaching, so that a pension will be due to them on their eventual retirement.

The remarks on research and consultant work are tempered by a like appreciation of the value of such conditions in attracting the right type of recruit, and in establishing the status and dignity which are essential for the maintenance of high professional standards. The major expansion in research in technical colleges should, in the Committee's view, be in the application of fundamental knowledge to problems of design and production; but it also urges the prosecution of research into teaching methods, particularly as applied to special branches of technology. The prime consideration is here the benefit to the teacher himself, though the value of both research and consultant work to local industry is not overlooked; from the same point of view the report stresses the importance of encouraging teachers to extend their technical knowledge and to improve their qualifications, of a liberal policy in regard to leave to attend scientific and technological conferences and of reasonable standards of accommodation.

Dr. Willis Jackson and his colleagues have produced a report which is pervaded by the same liberal spirit and understanding of the mind of the scientist and technologist as marked the Barlow Report on scientific staff more than a decade ago. Whereas, however, implementation of the recommendations of the latter report was a matter for Government administrators alone, those of the present report are addressed to industry, to local education authorities and to many others, including the college authorities, many government bodies as well as the Ministry of Education and professional associations and the teachers themselves. To bring a more liberal outlook into technical education also depends on wide-spread co-operation, and all these considerations give special importance to the two novel proposals of the report.

First, the Committee is convinced that residential conferences, lasting two or three weeks, for senior members of the staff of technical colleges, would be of considerable benefit, alike in identifying and studying major problems connected with the aims, ideas and growth of technical education, stimulating new methods and attitudes in the colleges, fostering a more catholic understanding of the functions of technical colleges and keeping teachers in touch with new trends in science and technology. Accordingly it is recommended that the Minister of Education should establish a staff college with its own board of governors and appoint a director of studies to plan the programme and guide its execution. Secondly, it is recommended that an advisory committee be established on the supply and training of teachers for further education, the duty of which would be to review the arrangements and provision for training and to keep in touch with the technical colleges as regards the supply of teachers and the demand for different types of training courses.

Time may well be required to implement these latter recommendations; nor can the proposal for further proliferation of the bodies concerned with technical education be entertained without careful consideration, if only on account of the demands it may make on the time of experienced and trained man-power. Meanwhile, however, the report sets forth—with cogency and a sense of urgency—practical ways in which professional bodies, technical college authorities, industrialists and teachers themselves could work together to meet a desperate need, and to establish the conditions which should ensure an increasing supply of teachers of high quality both for colleges of technology and for the technical colleges. Not the least of these opportunities, and one for which every scientist and technologist shares some measure of responsibility, is that of educating public opinion as to what is involved and thus securing the public understanding needed both to ensure a steady supply of students for the colleges and the adoption of the appropriate measures by local education authorities.

TERMINOLOGY IN PHYSICS AND ELECTRONICS

The International Dictionary of Physics and Electronics

Pp. xvii+1004. (London: Macmillan and Co., Ltd., 1956.) 120*s*. net.

PHYSICS has derived its vocabulary from several sources. Unlike some other sciences it has always made much use of everyday words, adapting their meanings, usually by restricting them, to the needs of experiment and theory and giving many a quantitative sense. Although it continues to absorb

words in this way, it has increasingly had to resort to supplementary sources. Thus the names of prominent physicists have provided many adjectives to qualify effects, theories, quantities and instruments in addition to being used as units. Much can be said for the practice, provided ambiguity and obscurity are avoided. No physicist misunderstands, for example, the terms Planck's constant, Curie temperature, Geiger counter or Doppler effect; the Faraday effect or the Ramsden eyepiece may demand a moment's reflexion, but the Thomas precession, the Ettinghausen effect and the de Sitter universe are best left to the specialists. A few names—Gauss, Fermi, Debye—are overworked. Many of the letters of the English alphabet and some of the Greek form a second source of widely used adjectives; some are abbreviations (for example, *F*-centre), some form a sequence (thus, *K*-, *L*-, . . . shells and, hence, *K*-capture) and a few were previously used as symbols (for example, *k*-space). Many new nouns, including isotope, lumen, positron, ferrimagnetism, had to be coined, not always with the approval of etymologists.

Electronics uses many of the words of physics, but, dealing so much with complex components and with effects not found naturally, has also required new words.

The need to define the words and terms of the two subjects has long been realized, and both national and international bodies have sought to meet it. Very few dictionaries have been produced, however, so that the new International Dictionary could be an important addition. Its authors are mostly American, supported by four from Britain, and they have made use of work by American physical and radio institutions; there is no specific reference to the British Standards Institution, however, which has dealt extensively with terminology in branches of applied physics and in radio.

The definitions given in the new Dictionary are well worded and the fuller explanations given of many of the commoner terms will be of value to students. The cross-referencing is adequate and a sense of proportion is maintained between pure and applied physics and between the abstract and the concrete. The excellent definitions of the many mathematical theorems, functions, equations and operations used in the two subjects deserve special mention. Terms in physical chemistry and in meteorology are included, but the extent to which the meteorological terms will be consulted may not justify their inclusion.

If a few criticisms are made they must not be read as detracting seriously from the value of the Dictionary. The diagrams, though not numerous (one is given twice, however), are not always well chosen; some electronic circuits are too complex and do not use uniform symbols. Some words, such as vocoder and frequency changer, mean different things in America and Britain, but only the American meanings are given. Finer differences between British definitions and those of America may cause a little confusion also. Does the *E*-layer of the ionosphere extend from 100 to 150 km. (British Standards Institution) or from 90 to 160 km. (as this Dictionary says)? Is a wave impedance deduced from transverse components (British Standards Institution) or from appropriate components (this Dictionary)? Although the entries total about 10,000, the following are some of those omitted: Bitter patterns, Nyquist diagram (or criterion), square-loop material, forward scatter, guard-ring, Vickers hardness (Brinell, Rockwell, Bierbaum and Moh are included), types of diamond, superfluidity (superfluid occurs in the definition of heat flush), Heaviside calculus, delta modulation, photodiode, cæsium clock and Ayrton–Perry winding. The titles of articles in a recent issue of an American physics journal contained several words not included (for example, super-paramagnetism and granulometry), but the fault could sometimes be with authors who coin new words before the need is fully established.

The distinction between the Zener and the avalanche effects is not made clear. Some American trade names of magnetic materials are included, for example, 'Hypernick' and 'Hypersil', but some, usually European, names of long standing, such as 'Stalloy', 'Alnico' and 'Radiometal', are not. The entries of some non-metric units might have been shortened to a few tables, or omitted. The editors were perhaps compelled to include such inelegant terms as blacker-than-black, bottoming (topping presumably for a *p-n-p* transistor), breakoffski, 'hot' (highly radioactive) and scram (to shut down a reactor); let their inclusion be a warning to scientists of language degradation.

Mistakes or misleading statements are rare. Meacham is misspelt once; electron diffraction does not show the wave-like character of electron *beams*, and frequency and non-linear distortion are better termed attenuation and amplitude distortion respectively. The dictionary can certainly be paid the compliment of being interesting; indeed, one has to guard against the risk of becoming so absorbed in the entries on the page at which it happens to open—and in the cross-references that one is led to—as to forget the particular entry that one intended to consult.

J. R. Tillman

SWEDISH EXPLORATION IN SOUTH AFRICA

South African Animal Life

Results of the Lund University Expedition in 1950–1951. Edited by Bertil Hanström, P. Brinck and Gustaf Rudebeck. Vol. 1: Pp. vi+518. Vol. 2: Pp. vii+576. Vol. 3: Pp. vi+492. (Stockholm: Almqvist and Wiksell, 1955 and 1956.) 68 Sw. Kr. per volume.

Linnaeus once wrote: "There is no place in the world with so many rare plants, animals, insects, and other wonders of Nature as Africa, and it seems as if they have been concentrated to the Cape". This interest in the flora and fauna of South Africa was shared by a number of Swedish naturalists, and a three hundred years old history of Swedish endeavour in this field culminates in a recent expedition organized by Prof. Bertil Hanström, and executed by Drs. Per Brinck and Gustaf Rudebeck, accompanied and assisted by their wives, Mrs. Gunvor Brinck and Mrs. Inga Rudebeck. The expedition, which was supported by grants from the Swedish Natural Sciences Research Council and from private funds, started in October 1950 and returned to Sweden in August 1951. In collaboration with South African biologists and biological institutions, large collections chiefly of invertebrate material were made from more than 350 localities in the Cape, Orange Free State, Natal, Transvaal, South-West Africa, Bechuanaland, Northern and Southern Rhodesia, Swaziland and Basutoland. On the whole, most of the collections were made from terrestrial and limnic biotopes, and they are the largest ever to

reach the Zoological Institute at Lund. From there they have been distributed to more than a hundred specialists in about twenty countries, and the results of their findings are to be published in a work of eight volumes under the title: "South African Animal Life". Three of these volumes have already appeared. Vol. 1 contains an introduction by Bertil Hanström, a short history of Swedish exploration of South African animal life during two hundred years, by Per Brinck, and a list of localities investigated by the expedition, by Per Brinck and Gustaf Rudebeck. Chapters 3–6 deal with Turbellaria, Solifugae, scorpions and Pedipalpi, Pseudoscorpionida, and a monograph on the whirligig beetles. Seventeen chapters on the Symphyla, Chilopoda and Insecta, and a first chapter on birds form the contents of Vol. 2, and Vol. 3 deals with a further eighteen insect groups, besides two chapters devoted to the Ixodoidea, and the Proterospermophora among the Diplopoda.

In the interest of speedy publication of the material, accounts of the various groups will appear as they are completed and not in systematic order. From the first three volumes it is abundantly clear that the series will make important contributions to our knowledge of the taxonomy and distribution of South African terrestrial and freshwater invertebrates and also vertebrates, as well as to the solution of the problems of the development, evolution, and age of the relic fauna of the southern part of the African Continent. The volumes are excellently produced, and are well illustrated by clear line drawings, maps and photographs. It is naturally impossible in this context to scrutinize the taxonomic merits of the individual contributions. Short articles on the zoogeography and ecology of groups, keys and check lists, and extensive bibliographies, add to the value of the taxonomic accounts.

We are witnessing here the birth of a faunistic work of great importance which, I am certain, will become a classic in its field. A courageous enterprise, inspired, no doubt, by Linnaean tradition, it sprung from an idea which occurred to Prof. Hanström while on a visit to South Africa for the purpose of collecting mammalian material for endocrinological studies. Collections of invertebrates made during field excursions convinced him of the justification for a special expedition equipped with modern ideas and tools, and after his return he succeeded in organizing an enterprise on which collectors, taxonomists and editors alike are to be congratulated.

O. Lowenstein

OXINE AND ITS DERIVATIVES

Oxine and its Derivatives

By R. G. W. Hollingshead. Vol. 3: Derivatives of Oxine—Part 1. Pp. vi+617–896+16. Vol. 4: Derivatives of Oxine—Part 2. Pp. vi+897–1211+41. (London: Butterworths Scientific Publications, 1956.) 42*s*. each volume.

THESE two volumes bring to completion a work of over 1,200 pages on 8-hydroxyquinoline (oxine) and its derivatives. This substance, known since 1880, was not used as an analytical reagent until forty-five years later. A short monograph on its use was published by Berg in 1933 and many original papers have been written in recent years. The preceding two volumes which appeared in 1954 gave an exhaustive account of the reagent and of its behaviour with almost every metal and in great detail. The main use of oxine is as a precipitant for aluminium, magnesium and zinc, but innumerable other applications in analysis were reviewed, some of which may stand the test of time. The author had preferred to include everything rather than to make a critical selection.

The third and fourth volumes, which have now appeared, are devoted to derivatives of 8-hydroxyquinoline, including its salts. Analytical applications are less numerous in these volumes, which are very largely concerned with descriptive organic chemistry. 8-Hydroxyquinoline, its salts and various derivatives have proved useful as bactericides, amœbicides and fungicides, and a chapter is finally devoted to a survey of theories and experiments on their mode of action in these respects.

The author is to be congratulated on a magnificent work of compilation. The volumes are excellently produced, with a subject-index to each volume, and in Volume 4 there is also a patent index and an index of authors. It is perhaps regrettable that a combined subject-index was not provided. The references to the literature include items extending into 1956. However, much of the descriptive chemistry, which greatly adds to the bulk of these two volumes, might have been curtailed or omitted, for any research worker in this field would certainly consult the original papers. The question may be asked: Can we afford publication on this scale about every organic compound which has practical applications?

G. M. Bennett

THERMOCHEMISTRY

Experimental Thermochemistry

Measurement of Heats of Reaction. Edited by Frederick D. Rossini. (Prepared under the International Union of Pure and Applied Chemistry by the Sub-Commission on Experimental Thermochemistry.) Pp. xv+326. (New York: Interscience Publishers, Inc.; London: Interscience Publishers, Ltd., 1956.) 7.80 dollars.

THIS book, which is written by experts for experts, deals chiefly with organic compounds; inorganic substances are scarcely discussed. The volume opens with a chapter entitled "General Principles of Modern Thermochemistry", taken mostly from "Chemical Thermodynamics", by F. D. Rossini (1950), and closes with a chapter by the same author entitled "Assignment of Uncertainties to Thermochemical Data", taken from Rossini and Deming (*J. Wash. Acad. Sci.*, 29, 416; 1939). The other twelve chapters which contain original contributions discuss fundamental constants; the calibration of calorimeters for flame and bomb reactions; standard states and corrections; and the combustion of organic oxygen, nitrogen, sulphur, chlorine, bromine and iodine compounds. Reactions other than combustion are treated in ten pages while the microcalorimetry of slow phenomena occupies fifty pages. A brief section deals with physicochemical standards for thermochemistry and the book ends with an inadequate subject-index of two pages containing references to ninety-nine items.

A beginner will not find here sufficient drawings or descriptions of apparatus to enable him to start work. Indeed he would search this book in vain for a description of the exact conditions necessary to ensure complete combustion when he calibrates his bomb

calorimeter by using benzoic acid. On p. 40 he will find that "If any soot is found outside the crucible, the experiment is rejected. . . . The weight of any soot found in the crucible is determined". However, p. 44 reveals that it is not easy to determine the weight of this soot. On p. 135 he will read, "In the benzoic acid experiments it is found that, with the proper crucible and pelleting, complete combustion occurs in all but a very few experiments". Nevertheless, he may receive some encouragement from the statement (p. 291) that "benzoic acid will burn completely to form carbon dioxide and water under proper conditions but that the investigator must be alert to the possibility of incomplete combustion". He may well conclude that there is much art in this science. One disadvantage of having employed thirteen writers to prepare this book is that certain subjects (for example, the corrections to standard states) have been treated several times. The opportunity should be taken in later editions to unify the text so that the space saved may be devoted to more detailed information on experimental procedures.

E. F. G. Herington

DIFFERENTIAL EQUATIONS

Differential Equations

By S. V. Fagg. (Applied Mathematics Series.) Pp. 128. (London: English Universities Press, Ltd., 1956.) 7*s*. 6*d*. net.

Differential Equations

By Prof. Harry W. Reddick and Prof. Donald E. Kibbey. Third edition. Pp. ix+304. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1956.) 36*s*. net.

Elementary Differential Equations

By William Ted Martin and Eric Reissner. (Addison-Wesley Mathematics Series.) Pp. xi+260. (Cambridge, Mass.: Addison-Wesley Publishing Company, Inc., 1956.) 5.50 dollars.

Ordinary Non-Linear Differential Equations in Engineering and Physical Sciences

By Prof. N. W. McLachlan. Second edition. Pp. x+271. (Oxford: Clarendon Press; London: Oxford University Press, 1956.) 35*s*. net.

Partial Differential Equations

By Prof. G. F. D. Duff. Pp. x+248. (Toronto: University of Toronto Press; London: Oxford University Press, 1956.) 35*s*. net.

Transactions of the Symposium on Partial Differential Equations

Held at the University of California, Berkeley, June 20–July 1, 1955. Editorial Committee: N. Aronszajn, A. Douglis and C. B. Morrey, Jr. (Sponsored by Office of Naval Research; University of California, Berkeley, Calif.; University of Kansas, Lawrence, Kan.; and the American Mathematical Society.) (Reprinted from Communications on Pure and Applied Mathematics, Vol. 9, No. 3, issued by the Institute of Mathematical Sciences of New York University.) Pp. vi+334. (New York: Interscience Publishers, Inc.; London: Interscience Publishers, Ltd., 1956.) 6.50 dollars.

THE set of six books under review divides naturally into two parts: three elementary text-books and three advanced expositions, one of which is a collection of papers delivered at a symposium. The text-books overlap considerably in content with various others on the same subject which are already in print, and it is perhaps unfortunate that so many elementary texts on differential equations are available. The time must surely come when a rationalization of policy with regard to the publication of technical text-books will emerge; but that time is not yet, and meanwhile students and teaching staffs have to face a baffling array of books covering much the same ground in the process of making a choice.

The book by Fagg has the merit of brevity (and hence low price) and it discusses numerous practical examples. Its appeal is at the school level, except for a chapter on the Laplace transform designed to whet the appetite of the more serious reader. Reddick and Kibbey also emphasize practicality, but their book is more extensive (although still elementary) and the third edition contains some new features, such as sections on partial differential equations and the adjoint equation, together with many new exercises. Martin and Reissner have written a book for students of science and engineering who "need to know mathematics rather well". Their text covers more ground than the two previous books and, in addition to a chapter on finite difference equations, describes methods for solving various heat-transfer problems.

The three other books are much more advanced and deal with research topics. McLachlan's book, a revised version of the 1950 edition, is based on lectures given to graduate students at the Universities of Illinois and Washington and at Michigan State University. Its purpose is "to provide engineers and physicists with a practical introduction to . . . non-linear differential equations, and to give representative applications in engineering and physics". This it does exceedingly well. It is not an analytical treatise with technical applications, but rather shows "how certain types of non-linear problems may be solved, and how experimental results may be interpreted by the aid of non-linear analysis". Included are chapters on equations having periodic coefficients or periodic solutions. Graphical and numerical solutions are emphasized, and four theorems are presented for dealing with singular points and stability criteria. The book should be of particular value to engineers concerned with control problems.

The theory of partial differential equations continues to develop; and Duff's book describes particularly advances which have been made over the past twenty years. Equations of the first and second orders are discussed "from the tensor calculus point of view", which is general and penetrating. There is a chapter on linear integral equations and another on the integration of the wave equation. The latter is concerned primarily with the method of Riesz, involving integrals of fractional order. The exposition is concentrated in places and the book is definitely one for the pure mathematician or very theoretical physicist.

The last book records most of the lectures given at a symposium. These lectures, delivered by specialists, cover a wide field. Some deal with local or regularity properties of solutions, others with equations arising in applied mathematics, and still others with numerical solutions and estimates for eigenvalues. A glance at the contents list reveals a very healthy activity in research on differential equations, and the current deep and widespread interest in the subject justifies the appearance of the books under review.

L. S. Goddard

British Trees

A Guide for Everyman. By Miles Hadfield. Pp. xxv+468 (150 full-page drawings). (London: J. M. Dent and Sons, Ltd., 1957.) 30*s*. net.

MR. M. HADFIELD has produced a thoroughly reliable and readable book on the trees to be found in the British countryside, in plantations and in gardens. "British Trees" is perhaps a misnomer for a book that describes the 'monkey puzzle', Douglas fir, Japanese larch, Atlantic cedar, deodar, Bhutan pine, Corsican pine, Monterey pine, tulip tree, catalpa and dozens of others which are not indigenous to Britain but are perhaps so common as almost to be considered native. The arrangement followed is that of Rehder in his "Manual of Cultivated Trees and Shrubs". Each species treated is illustrated by clear line drawings to scale which show the leaf, long and short shoots, buds, flowers and fruit. These should render identification easy. The text gives a description of the species and also much interesting and entertaining information about the tree, its variations and its forms. The diseases and pests to which the species are prone are also mentioned.

The book is well got up and printing errors and mis-statements are few, though the compositor went astray with the epithet 'bignonioides', since the variants 'bignoniodes' and 'bignoniodies' are to be found in the index. *Gleditsia* is recorded as having a smooth bark. That may be true, provided one disregards the fearsome branched thorns one finds upon it.

The author holds strong views about botanical nomenclature. "Botanical nomenclature, unlike botanical classification, is empirical, unscientific, and occasionally grossly misleading." I, myself, hold strong views about his strong views and will be content to call this statement grossly misleading. This clash of opinions will not prevent me from recommending this work as a really excellent reference book, which should find its place on the shelves of every tree lover.

N. L. Bor

New Pathways in Cellular Pathology

By Prof. Gordon Roy Cameron. Pp. vii+90. (London: Edward Arnold (Publishers), Ltd., 1956.) 16*s*. net.

IN 1954 and 1955 Prof. G. R. Cameron gave two lectures in Leeds and Dublin on the cell, which aroused so much interest that he was persuaded to expand them into a monograph, and this attractive little book is the result. He summarizes modern views on the different parts of the cell, with chapters on cell-surface, cytoplasm, nucleus, mitochondria, microsomes and other cell components. There are forty-two figures showing sections of tissues, enlarged with optical microscopes and with electron microscopes, and diagrams of cell structure and of biochemical changes. The whole book can be read in an hour or two, and it gives an interesting picture of the way modern pathologists have not only been able to use new techniques to extend our knowledge of structure but have also started to find out something about the biochemical functions of the different structures.

Some of the best parts of the book are based on work done in Prof. Cameron's own laboratory and cover a wide range of topics. In recent years he and his colleagues have, for example, shown that some of the effects of thioacetamide on the respiration of liver cells are due to the accumulation of calcium in the liver. They have obtained evidence that much of the damage done by carbon tetrachloride is due to physical changes in the mitochondria, which lose coenzymes and eventually become converted into vacuoles. They have managed to produce copper deficiency in rats, and found it to be associated with a failure to synthesize phospholipid and eventually with loss of cytochrome oxidase in the mitochondria. Such studies are throwing fundamental light on pathological processes. This book opens the window to a view of the pathology of the future.

J. H. Gaddum

Le Ciel et la Terre

André Danjon, Pierre Pruvost, Jules Blache (Directeurs). (Tome III de l'Encyclopédie Française.) Pp. 452+32 planches. (Paris: Librairie Larousse, 1956.) Cartonnage souple, 7,450 francs; similoid, 8,850 francs; parchemin véritable, 11,950 francs.

IN this unusual volume, thirty-six leading French astronomers, geologists and geophysicists have co-operated in the production of a remarkably complete and readable guide to modern developments in their respective fields. About one-third of the book (140 large quarto pages of text and most of the plates) is devoted to astronomy and is divided into four sections: "The Earth and Solar System", "The Sun and Stars", "Galaxies" and "Evolutionary Problems". The remainder is divided into three sections: "The Terrestrial Globe", "The Earth's Crust", and "The Formation of the Earth's Relief". Each section is divided into one or more chapters, which in turn contain articles contributed by various authors. The book is bound in a loose-leaf filing system, so that it may be kept as up to date as possible by adding further articles from time to time as they are published.

The authors have succeeded in compressing a large amount of information into a few words in such a way that the results and the main lines of argument stand out very clearly; the reader is then referred to other works for the detailed theoretical and experimental developments. The emphasis is on the results of recent research throughout, the more 'classical' fields being only briefly summarized. The illustrations are excellent, and the editors have succeeded in welding the various contributions into a coherent and unified text. Only the bibliography (at the end of the book) appears to be somewhat too restricted.

Bernard Pagel

Reports on the Progress of Applied Chemistry

Vol. 40, 1955. Edited by H. S. Rooke. Pp. 1000. (London: Society of Chemical Industry, 1956.) 60*s*.

THIS very useful annual review of progress in chemical industry continues to maintain its position as a guide to a very large field of work. The articles are written by specialists and cover the literature very adequately. The one on the corrosion of metals, for example, dealing with the work of one year, has 150 references. In some cases, as in the section on animal and vegetable oils, there are summarizing tables. There is an interesting description of radioactive tracer elements, and the section on synthetic fibres records progress in this field. Very complete indexes make it easy to find information on any topic dealt with in the book.

J. R. Partington

THE JODRELL BANK RADIO TELESCOPE

By Prof. A. C. B. LOVELL, O.B.E., F.R.S.

THE large radio telescope which has been built at the Jodrell Bank Experimental Station of the University of Manchester is nearly complete. It is frequently stated that the instrument is the largest radio telescope in existence. This is quite erroneous without a good deal of qualification. The telescope is essentially a paraboloidal steel bowl 250 ft. in diameter, with the focus in the aperture plane, built so that it can be directed towards any part of the sky. It is, therefore, relatively small compared with many radio telescopes elsewhere. For example, aerials of the 'Mills Cross' type have been built with an extension of more than a mile, and even one element of Ryle's adjustable cylindrical parabolic interferometer system which is nearing completion near Cambridge has a 50 per cent greater surface area. Nevertheless, the instrument at Jodrell Bank is believed to be by far the largest completely steerable pencil-beam type of radio telescope in existence, although considerable uncertainty exists as to the Russian facilities in this type of work. Its nearest operational competitors in size are the 80-ft. diameter telescopes at Dwingeloo in Holland, and near Bonn in Western Germany, although both these instruments are figured to a much higher degree of accuracy and are designed for work on much shorter wave-lengths than the Jodrell Bank telescope. In the next few years it is expected that 90-ft. aperture radio telescopes will be built at the California Institute of Technology, a 140-ft. instrument for the U.S. National Radio Observatory of Associated Universities Incorporated at Greenbank, Virginia, and one of 200- to 300-ft. aperture near Sydney. Hence, even although the British instrument has taken two years longer to build than originally specified, it is likely to rank as the major instrument of this type for radio astronomical research for a considerable time.

The engineers responsible for the telescope are Messrs. Husband and Co., of Sheffield and London. When the idea for the instrument was first put forward in 1948 and 1949 many engineers refused to consider the possibility of its construction. Mr. H. C. Husband, however, believed that the task could be accomplished, and the results of his work and of his team of designers now stand in the shape of more than two thousand tons of steel on the Cheshire plain. In principle the motion of the telescope is altazimuth. The bowl, which weighs about seven hundred tons, is driven in elevation by a Ward–Leonard system through two 27-ft. racks from the dismantled battleship *Royal Sovereign*. These are mounted 170 ft. above ground on two towers which themselves rotate on a 350-ft. railway track to give the motion in azimuth. The drive is through two bogies under each tower, again through a Ward–Leonard system. Four additional bogies, which are undriven, serve as wind carriages on each side of the structure. The towers are connected near ground-level through a heavy diametral girder system supported on the central pivot which is the fundamental locating part of the telescope. The power and instrumental cables come through this central pivot into a motor room situated within the diametral girder immediately above the central pivot. This room contains the motor generator sets and controls for the Ward–Leonard system.

The 17-ft. gauge double railway track on which the telescope rotates is mounted on deep-piled foundations

Fig. 1. The Radio Telescope at Jodrell Bank nearing completion. In the foreground is Prof. A. C. B. Lovell

which extend in some places to 90 ft. underground. The various power, control and instrumental cables are taken into an annular laboratory underneath the central pivot and then through an underground tunnel to the control room. This control room houses the main control racks and console. The computer system consists of magslip resolvers working in servo loops to solve the necessary equations in order that the telescope can be given a sidereal movement. A wide range of movements can be selected at the control desk, for example, automatic sidereal motion at a given right ascension and declination, motion in galactic latitude and longitude, straightforward motion in azimuth and elevation, and various automatic scanning movements with a choice of rasters. Parallax corrections can also be introduced when it is desired to track a body in the solar system. There are no slip rings so that the danger of creating electrical interference is avoided, and the limit of motion is 420 degrees, after which an automatic reversal takes place.

The specification calls for a tracking accuracy of at least 12 minutes of arc at speeds up to 4 degrees per minute. The maximum slewing speed is about 22 degrees per minute in azimuth and elevation. The position of the telescope in azimuth and elevation is repeated back to the control room through magslips driven by accurately machined chain racks independently of the driving system. The specification requires these positions to be repeated to an accuracy of $\pm$ 1 minute of arc.

The reflecting membrane is of $\frac{1}{12}$ in. thick steel sheet welded from 7,000 individual sections of about 3 ft. × 3 ft. on to the purlins of the steel framework. It has been essential to ensure good conductivity across these welded sections otherwise the membrane would become very lossy at certain wave-lengths. The primary aerial feed is carried at the focus on a steel tower built up 62½ ft. from the apex of the paraboloid.

Fig. 2. Underside of the bowl showing the stabilizing wheel, which is 280 ft. in diameter, and the hanging laboratory

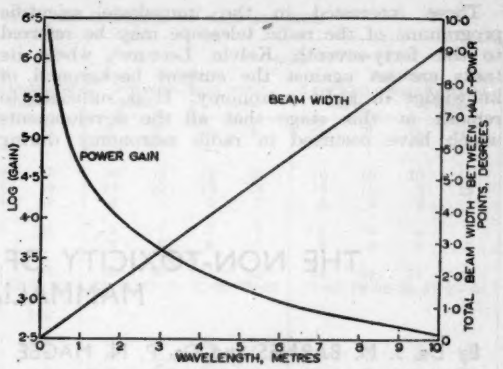


Fig. 3. Calculated power gain and beam width of the 250-ft. aperture radio telescope as a function of wave-length

This tower diminishes in cross-section rapidly with height in order to avoid obscuration and scattering from the primary feed. It was, however, essential to design it with sufficient stiffness so that no displacement occurred as the bowl turns over. An important scientific requirement is that easy access can be attained to the primary feed so that the operational wave-length can be changed readily. Originally it was intended to have an access tower which could move out on tracks on top of the diametral girder to put the operator in reach of the aerial when the bowl was inverted. This was later abandoned in favour of a system whereby the aerial is mounted on a 50-ft. steel tube which slides into the top of the aerial tower. With the bowl inverted this can be winched down to ground-level and replaced by another 50-ft. tube complete with aerial system. The radio-frequency cables from the aerial run inside this tube and can be reached from a small platform near the base of the tower when the bowl is facing towards the zenith.

In much of the work it will be necessary to mount the radio-frequency pre-amplifiers and other parts of the receiving equipment as close as possible to the aerial. These essential units will be contained in a small laboratory which swings underneath the bowl. Further laboratory space is available at the tops of the two towers, but even from those the minimum length of cable run to the primary feed is about 200 ft. Other scientific apparatus will be installed on the base girders ; but the main recording apparatus will be in laboratories adjacent to the control room.

From the astronomical point of view the success of the engineers will be judged by the accuracy with which the telescope moves and the extent to which the reflecting membrane retains its paraboloidal shape in different aspects and under various wind conditions. The theoretical curves showing the beam width and power gain as a function of wave-length are shown in Fig. 3. Calculations have been made of the effect of irregularities in the membrane on the power gain, from which it is clear that, except at very short wave-lengths for which the telescope is not primarily designed, large distortions are permissible without any appreciable effect on the performance of the telescope. During the next few months it is hoped to begin the scientific programme by establishing these curves on an experimental basis by observing certain radio sources at different azimuths and elevations over a range of wave-lengths.

Those interested in the immediate scientific programme of the radio telescope may be referred to the forty-seventh Kelvin Lecture[1], where its tasks are set against the current background of knowledge in radio astronomy. It is sufficient to remark at this stage that all the developments which have occurred in radio astronomy during the past years have served to underline the importance of this telescope. With this instrument, together with the large interferometric systems in Cambridge, Great Britain can reasonably look forward to a most fruitful period in radio astronomy.

[1] Lovell A. C. B., *Proc. Inst. Elec. Eng.*, **103**, 711 (1956).

THE NON-TOXICITY OF MALEIC HYDRAZIDE FOR MAMMALIAN TISSUES

By Dr. J. M. BARNES and Dr. P. N. MAGEE
Toxicology Research Unit, Medical Research Council Laboratories, Carshalton

Prof. E. BOYLAND, Prof. A. HADDOW and Prof. R. D. PASSEY
Chester Beatty Research Institute, Fulham Road, London, S.W.3

Prof. W. S. BULLOUGH
Department of Zoology, Birkbeck College, London, W.C.1

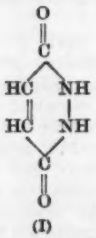
Dr. C. N. D. CRUICKSHANK
Unit for Research on the Pathology of the Skin, University of Birmingham

Dr. M. H. SALAMAN
Cancer Research Department, London Hospital Medical College, London, E.1

AND

Prof. R. T. WILLIAMS
Department of Biochemistry, St. Mary's Hospital Medical School, London, W.1

In 1949 maleic hydrazide (1), 1 : 2-dihydropyridazine-3 : 6-dione, was introduced as a plant growth regulator and has since found a number of important commercial uses as a selective weed killer and as a depressant of plant growth in a variety of circumstances. The mode of action of maleic hydrazide on the plant cell is not clearly understood. There is some evidence that it may interfere with the metabolism or action of the natural growth regulators of plant cells (auxins)[1,2].



(I)

By the conventional tests used to study mammalian toxicity, maleic hydrazide appears to be virtually harmless, and large doses are tolerated by rats, mice, guinea pigs, dogs and hens. The *LD*50 for rats is stated to be 4 gm./kgm. and rats were unaffected by a life-time on a diet which contained up to 1 per cent maleic hydrazide[3]. In confirmation of this, we observed in preliminary experiments no effect on the growth of young rats receiving a diet containing 1 per cent maleic hydrazide. The fact that the growth of plant cells may be affected by concentrations of 0·001 per cent suggests that the action of maleic hydrazide is in some way specific for plant, as distinct from mammalian, tissues. However, during the study of the action of maleic hydrazide on *Vicia faba* roots, Darlington and McLeish[4] found that the arrest of cell division was accompanied by chromosome breakage. They noted that maleic hydrazide causes breakage of the heterochromatin of the plant cells, whereas X-rays break only the euchromatin. Nevertheless, they concluded as follows: "Since nearly all chromosome breaking agents have so far proved to be cancer producing as well, we must hope that the agricultural use of this new agent will not be encouraged before suitable tests are made".

What follows is a summary of the work that has been done since the above communication appeared, in an attempt to show whether or not maleic hydrazide possesses any carcinogenic properties for mammalian tissues. In the meanwhile, the warning had been taken very seriously by makers and users of maleic hydrazide in Britain, and the use of maleic hydrazide has been restricted to situations where contamination of food crops would not occur. Nevertheless, there are potential uses for maleic hydrazide in suppressing sprouting of stored vegetables, for example, where food contamination might take place. Apart from the specific problem as it relates to maleic hydrazide, this account illustrates some of the difficulties of accumulating satisfactory evidence in order to substantiate the negative assertion that a given substance is not a carcinogen.

Soon after Darlington and McLeish's communication appeared, experiments were started at the Chester Beatty Research Institute in which solutions of maleic hydrazide (1 c.c. of the diethanolamine salt, each c.c. containing 5 mgm.) were injected subcutaneously at approximately weekly intervals for fourteen months into rats. Of the total of fifty-two rats so treated in two experiments, three developed sarcomata, whereas of the controls receiving saline none developed tumours. Although rats develop sarcoma after the injection of foreign materials, the incidence in this particular experiment was unusually high and a further experiment was planned using rats and mice. The results from this experiment are summarized in Table 1. Groups of young males and females of each species were given maleic hydrazide either by a weekly subcutaneous injection of a dose of 500 mgm./kgm. (monosodium salt) in aqueous solution or

Table 1. Test for Carcinogenic Properties of Maleic Hydrazide on Rats and Mice

Species	Rats								Mice							
Route of administration	Injection 500 mgm./kgm./week				Feeding 1 per cent maleic hydrazide				Injection 500 mgm./kgm./week				Feeding 1 per cent maleic hydrazide			
Sex	Male		Female		Male		Female		Male		Female		Male		Female	
Group *C* = Control *T* = Treated	*C*	*T*	*C*	*T*	*C*	*T*	*C*	*T*	*C*	*T*	*C*	*T*	*C*	*T*	*C*	*T*
Numbers:																
1. Start	10	14	10	15	10	15	10	15	10	15	10	12	10	15	10	15
2. Alive at 52 weeks	8	12	10	15	8	13	8	14	10	15	10	12	10	15	9	15
3. Alive at 100 weeks	4	2	2	5	3	4	4	5	0	0	6	3	3	4	3	4
4. Histological examination	9	11	9	15	8	14	9	14	3	7	7	7	3	9	4	8
5. Autopsy only*									2	6	0	1	5	3	3	6
Average survival† (weeks)	84	72	88	72	85	67	61	76	83	85	81	83	94	89	74	90
Range	38–98	7–90	61–99	52–93	17–98	25–96	8–83	38–96	72–91	57–89	73–93	71–89	77–98	79–99	19–97	77–98
Gain in weight‡ (gm. in first 52 weeks)	406	360	206	228	272	263	177	163								
Tumours:																
Malignant	0	0	1	1	0	1	0	1	0	0	0	1	0	0	0	1
Lymphoma	2	0	0	1	1	0	0	0	0	0	4	2	0	0	0	1
Benign	0	0	3	5	0	1	2	3	1	4	2	2	1	2	0	5
Total	2	0	4	7	1	2	2	4	1	4	6	5	1	2	0	7

* In many mice autolysis was too far advanced to make histological examination worth while.
† The survival time of those animals that died in less than 100 weeks.
‡ Rats receiving the diet as a powder grow less rapidly and do not reach the final weight of those receiving the diet as cubes.

received a standard diet (*MRC* 41 in powder form) containing 1 per cent maleic hydrazide added as a dry powder. The experiment ran for 100 weeks. Control animals received weekly injections of the same volume of saline or the same powdered diet without the addition of maleic hydrazide. Unless post-mortem autolysis was advanced, macroscopical and microscopical examinations of all the dead animals were carried out. As the majority of the animals were aged at the time of their death, they showed a wide range of pathological changes in their organs, particularly in the lungs and kidneys.

Clearly maleic hydrazide had no effect on the growth and general health of the rats or mice. A special search was made for tumours and many doubtful lesions were subjected to special and independent scrutiny by two of us (R. D. P. and P. N. M.). The most common tumours were the fibroepithelial mammary tumours in the female rats and lung adenomata in mice. These tumours were of the types commonly encountered in the ordinary laboratory strains of rats and mice. The possible malignancy of some of these tumours may be a matter of debate, but in this experiment the types found in the control animals did not differ from those seen in the groups receiving maleic hydrazide. Lymph gland tumours (lymphomas) were also seen in both species. Tumours of undoubted malignancy included two sarcomata and four carcinomata of the lungs. When the results were collected it was clear that the administration of maleic hydrazide by mouth or by weekly injection to rats and mice over a period of two years had not resulted in any increase in the incidence of tumours (Table 2). In this experiment,

Table 2. Summary of Tumours found in Rats and Mice receiving Maleic Hydrazide

Tumour	Rats		Mice	
	Control	Treated	Control	Treated
1. Fibroepithelial mammary tumour	5	7	—	—
2. Lymphoma	3	1	4	3
3. Adenoma of lung	—	—	5	10
4. Carcinoma of lung	1	2	—	1
5. Hepatoma	—	—	1	1
6. Fibroma	—	1	—	—
7. Sarcoma	—	1	—	1
8. Pituitary adenoma	—	1	—	—
Total incidence	9/40	13/59	10/40	16/57

twenty-nine rats received weekly subcutaneous injections of maleic hydrazide, but only one of the animals developed a sarcoma at the injection site. This contrasts with the figure of three out of the total of fifty-two noted in the preliminary experiment which was carried out on rats of the same stock.

The possibility that any carcinogenic property possessed by maleic hydrazide might be enhanced by the administration of a co-carcinogen was tested by applying maleic hydrazide with croton oil to mouse skin. Two mice developed tumours out of twenty-one treated, but seven mice out of fifty-three developed tumours with croton oil treatment alone[5]. This finding indicated that maleic hydrazide had no tumour-initiating action on mouse skin (for definition see Salaman and Roe, *Brit. J. Cancer*, **7**, 472; 1953). Further tests for carcinogenicity by prolonged application alone to mouse skin were not carried out, because so far it has been found that all substances carcinogenic for mouse skin are also initiators of carcinogenesis in the same tissue. (However, not all initiators of carcinogenesis are also carcinogenic in mouse skin, though they may be for other tissues.)

In a further experiment, pellets of cholesterol containing 20 per cent maleic hydrazide were implanted into the bladders of mice. No tumours developed in a group of fourteen mice which survived forty weeks[6].

Further work was done in order to see whether maleic hydrazide displayed any action on growing mammalian cells. Large doses (125 mgm./kgm.) were given to rats bearing Walker tumours, but no effect on tumour growth or cell mitosis was observed. The effect on mammalian cells was further examined by studying the development of mitosis in fragments of mouse ear epidermis grown in a phosphate buffer containing glucose. In concentrations from 0·0001 to 0·001 *M*, maleic hydrazide had no effect on mitosis or cell division in the mouse epidermis.

Maleic hydrazide was also tested upon skin from the guinea pig's ear grown in tissue culture in a medium containing serum, glucose, Krebs–Ringer phosphate and streptomycin hydrochloride. Up to a concentration of 0·01 *M*, maleic hydrazide had no gross or microscopical effects upon the explants. The same concentration of maleic hydrazide was also without effect upon the respiration of skin cells studied 2 and 22 hr. after adding the maleic hydrazide.

An attempt to follow the metabolism of maleic hydrazide in mammals was made in a study on rabbits. After an oral dose of 100 mgm./kgm., 43–62 per cent of the maleic hydrazide was excreted unchanged within the first 48 hr. With larger doses (2 gm.), the unchanged maleic hydrazide was isolated and characterized as its benzylamine salt. No other metabolites such as glucuronides or ethereal sulphates were found, so that the 40 per cent maleic hydrazide unaccounted for may either be excreted slowly over long periods or else is broken down and destroyed.

In conclusion, it may be stated with reasonable certainty that maleic hydrazide is without significant effect on the growth of normal mammals or isolated mammalian tissues. This is strong evidence against maleic hydrazide having any activity comparable to that of well-known carcinogens. The absence of any significantly greater number of tumours in male or female rats and mice receiving maleic hydrazide by two routes over a period of two years makes it improbable that it is even a weak carcinogen for these species or that some metabolite of maleic hydrazide has any such effect. A further study of the mode of action of maleic hydrazide on plant cells may perhaps eventually help us to understand why the chromosomes of plant cells but not those of mammalian cells are broken when cells are acted on by maleic hydrazide. Meanwhile, it seems reasonable to claim that proper tests have now been made, and the weight of evidence provided by the results of these tests is that maleic hydrazide has no carcinogenic properties.

We wish to thank Mr. C. R. Kennedy (Medical Research Council Toxicology Research Unit) for his work in maintaining the long-term experiment on rats and mice. Messrs. Whiffen kindly supplied a specially purified sodium salt of maleic hydrazide for the experiment.

[1] Leopold, A. C., and Klein, W. H., *Science*, **114**, 9 (1951).
[2] Waggoner, P. E., and Dimond, A. E., *Science*, **117**, 13 (1953).
[3] Information from Naugatuck Chemical International, New York, U.S.A.
[4] Darlington, C. D., and McLeish, J., *Nature*, **167**, 407 (1951).
[5] Salaman, M. H., and Roe, F. J. C., *Brit. J. Cancer*, **10**, 363 (1956).
[6] Allen, M. J., Boyland, E., Dukes, C. E., Horning, E. S., and Watson, J. G., *Brit. J. Cancer* (in the press).

ATOMIC ENERGY AND ITS BIOLOGICAL IMPLICATIONS*

By Sir JOHN COCKCROFT, O.M., K.C.B., C.B.E., F.R.S.
Director of the Atomic Energy Research Establishment, Harwell

THE feasibility of the large-scale generation of electricity from nuclear energy has been demonstrated during the past year by the commission and operation of the Calder Hall nuclear power station. This power station, which derives its heat from two nuclear reactors, generates 90 megawatts of electricity, of which about 20 megawatts are used internally to drive the blowers which circulate the carbon dioxide gas used for transfer of heat. Most of the net output of electricity flows into the British National Grid. Our experience in the start-up and operation of this reactor has been very satisfactory. We have had few troubles associated with the nuclear part of the system—indeed, there is very little except the fuel elements to go wrong. Each reactor contains 10,000 fuel elements, consisting of uranium rods sheathed in a magnesium alloy. The function of the sheath is to prevent oxidation of the uranium by the hot carbon dioxide gas, and to contain the radioactive fission products which are produced in the chain reaction. Very great care is taken in the sealing of the magnesium cans and only three failures of the seals have been discovered in twelve months of operation. The failures are due to a slight crack developing usually in a weld and a small amount of radioactivity leaks into the heat transfer gas. This is at once detected by electronic devices and the defective fuel element is then removed. In future power stations the fuel elements are expected to stay in the reactor for four or five years, by which time each ton of uranium will have developed the heat equivalent of 10,000 tons of coal. At the end of this time the chain reaction would slow down, so the fuel elements have to be changed. They are withdrawn by a mechanical discharge machine (which is heavily shielded) and then sent down a chute into a pond, where they lie shielded by a depth of 10 ft. or so of water for about 100 days.

During this time the radioactivity of the short-lived radioisotopes decreases. The activity of radioiodine, for example, which has a half-life of eight days, decreases about 6,000-fold. The fuel rods are then sent to the chemical processing plant at Windscale and dissolved. In this process the volatile fission products, such as radioiodine and the fission gases, radioxenon and radiokrypton, are at present allowed to escape from a high stack, but the activity at ground-level is well below the accepted tolerance level. Radioiodine can be detected in the thyroids of sheep grazing grass nearby, but again the activity is too low to be harmful.

The other radioactive waste products are separated from the spent uranium and the plutonium in the chemical plant. The waste products are concentrated by evaporation and then stored in large stainless steel tanks. The actual physical volume of the waste is very small and the cost of storage of the wastes is likely to contribute only 1 or 2 per cent to the cost of nuclear power. We have started to separate from the waste products radioactive cæsium and strontium and to use these for medical and industrial purposes. Thus a new 1,000-curie source of radiocæsium has been made for the Royal Marsden Hospital for cancer therapy. The radiocæsium emits 0·662-MeV. gamma-rays and has a half-life of about thirty years. It has the advantage of emitting a more penetrating radiation than that available from most X-ray sets, and requires little or no maintenance.

* The substance of the Fison Memorial Lecture delivered at Guy's Hospital Medical School on May 31.

We expect to produce about ten such sources a year for the next two or three years, and after that to produce still larger sources for industrial use.

Besides these highly radioactive wastes, we usually have radioactive effluents arising from plant washings, laundering clothes and so on. We treat these in an effluent-treatment plant and reduce the activity ten- or twenty-fold by standard precipitation methods. The remaining activity is then so low that it can be dispersed through a large pipe-line into the sea, where normal mixing processes dilute it into about 10^{12} cm.^{3} in the course of a single day, by which time the average of activity is within the level at which it could be drunk safely if it were not saline. Extensive biological monitoring of the activity levels in fish, seaweed and on beaches ensures that the effluent discharges are limited to activity levels which cannot possibly produce any harmful effects. These levels are prescribed by the responsible Ministry.

Although a nuclear power station does not itself discharge more than minute traces of radioactivity to sea and air, the operating reactor is a powerful source of radiation. Indeed, a Calder Hall reactor emits radiations as powerful as about 1,000 tons of radium. For this reason the reactors are enclosed in thick concrete walls known as the biological shields. The thickness is such that at the outside surface of the shield the radiation is at the so-called 'maximum permissible level', which means that during a working week an operator exposed full-time to this radiation could receive a maximum dose of 0·3 rem.

Inside the biological shield the radiation intensity is much higher, even if the reactor is shut down. On some occasions maintenance work has to be carried out. Whenever possible, this is done by remote handling devices, sometimes guided by a television eye. In very rare cases where human beings have to enter regions of high radiation intensity, the operation is so timed that the integral dose received is kept to a very low level of 1–2 rem. The integral dose of even the most highly exposed employees is limited to 5 rem a year.

The most remarkable example of remote repairs was the complete dismantling of the Chalk River heavy-water nuclear reactor, following a reactor accident in which no one was hurt. By an elaborately controlled operation lasting about a year, the whole interior was dismantled progressively. There were no significant over-exposures—either in the accident itself or in the laborious dismantling process—to external radiation or to the dangerous strontium-90 isotope in the fission-product contamination. So we are rapidly learning how to work with intense radioactivity in complete safety.

In the operation of research reactors there are similar but somewhat more difficult problems, since the shield of the reactor is pierced by numerous holes normally sealed by concrete plugs which can be withdrawn to allow beams of neutrons to emerge. Radiation levels above the maximum permissible level occur near the emergent beams, which must therefore be carefully labelled by notices, and avoided by the people working with them.

The monitoring of working conditions, both for external radiation from gamma-rays or neutrons and to prevent the risk of inhalation or ingestion of fission products, is carried out by health physicists, whose job it is to see that workers do not receive more than the permissible exposure. Individual workers carry film-badges which are developed weekly so that individual doses are recorded. In addition, they may carry pocket dosimeters, and are equipped with a range of portable and installed radiation monitors and alarm devices around reactors which help the health physicists and other staff to ensure that over-exposure does not occur. A similar close watch is kept on the chemical laboratory, where the chemists may be working with highly active sources, and in all high-activity areas continuous-running radioactive dust monitors and radiation alarms are installed. An occasional spill may produce radioactive contamination on the floor and in the air which has to be prevented from spreading. For this purpose a decontamination squad is available—if necessary, dressed in frog-suits.

The basis of the permissible levels of exposure has been worked out over a long period of years. In the early days of exposure to X-rays there were many examples of serious harm to individuals due to excessive doses of radiation. In the Cavendish Laboratory where I worked we had cases of skin trouble in assistants handling radium. I remember a demonstration of X-ray pictures being given which led to skin burns; in my own experimental work we used to hold up a fluorescent screen in our laboratory and judge the intensity of the radiation to which we were exposed by the intensity of the glow. If it was too bright we added another millimetre of lead shielding. It is remarkable that we are alive and well to-day.

When we started our war-time Anglo-Canadian atomic energy project at Chalk River, we had more appreciation of radiation hazards, and two of the first members of our staff were senior university radiobiologists. They took charge of our radiological protection, and since then have played a major part in working out the radiological protection policy of Great Britain. Radiological protection has been superintended since 1946 by the M.R.C. Radiological Protection Committee and the International Commission on Radiological Protection. These bodies have worked out a long list of 'maximum permissible levels'. For example, the maximum dose of radiation to the whole body in one week is laid down as 0·3 rem The maximum quantity of plutonium which may be retained in the system by occupationally exposed workers is 0·04 microcurie; the maximum amount of strontium-90 is 1 microcurie. The basis of the permissible levels for ingested materials such as radium and plutonium is the extensive experience with radium in human beings from instances among radium dial painters who afterwards developed bone tumours, and from early therapeutic and diagnostic practice. Animal experiments by Brues were the basis of determination of the relative effects of radium and strontium. Further studies are in progress by the Committee of the Medical Research Council. The whole subject of the radiation exposure of man was reviewed a year ago by a committee of the Medical Research Council which was set up specifically to report on the hazards to man of nuclear and allied radiations. A similar committee was appointed by the U.S. National Academy of Sciences and both committees reported a year ago. Their recommendations were remarkably similar.

Some important new information was presented to the Medical Research Council Committee on the effect of radiation in inducing leukæmia. This came from investigations, conducted by Court Brown and Doll, on the case-histories of a particular treatment

in British hospitals for ankylosing spondylitis. Broadly speaking, the natural incidence of leukæmia, which is about 1 in 20,000 per year, was increased three- to ten-fold in these cases by a radiation dose of 200 roentgens. However, when radiation is received at smaller dose-rates, evidence from mice suggests that the effect on leukæmia production would be less. Mole's experience at the Medical Research Council Radiobiological Research Unit with mice and their radiation-induced leukæmia (which is a poor model for human leukæmia, but the best available) is that "with total doses of 500–1,000 r. the incidence of leukemia may depend very markedly on whether the dose is given by continuous irradiation (from a cobalt-60 source) or in a series of brief exposures each at a relatively high dose (from an X-ray machine)". Nevertheless, the Medical Research Council Committee recommends that the life-dose for occupationally exposed workers should be limited to 200 rem.

A further measure of protection to occupational workers was suggested—that the dose to the gonads up to the age of thirty should be limited to 50 rem. This limit was set for a different reason—to prevent the chance of conceiving an abnormal child being increased by more than a marginal value. For example, the incidence in the population of severe mental deficiency in children which survive has been estimated to be about 1 : 500. If the mutation rate had been doubled by radiation in one parent the chance of producing a defective child would be increased by about 1·5 per cent. For this reason, the permissible dose up to the age of thirty has now been limited to 50 rem and the average yearly working dose to 5 rem.

Another important recommendation of both reports was concerned with the genetic protection of the human race as a whole. It is well known that radiation can increase the rate of mutation substantially above the spontaneous mutation rate, the mutants being of identical character as far as is known. A common mutant is that producing schizophrenia. There are about 63,000 cases under hospital care in Britain at the present time. Doubling the mutation rate by radiation would lead to 200 more cases in the first generation of 20 million births in Britain and 63,000 more cases for hospital care in the very long term. The American report predicted that a doubling of the mutation rate would lead eventually to an additional 2,000,000 instances of tangible inherited defect in the United States.

It is therefore important to know quantitatively how the mutation rate increases with the cumulative radiation dose up to the age of procreation. The only worth-while evidence so far comes from experiments on fruit-flies and mice. These experiments have been carried out on only a few readily identifiable types of mutations. The statistics, such as they are, suggest that the mutation rate increases linearly with cumulative radiation doses up to about 600 rads. So the curve of mutation rate against this will have an intersection at zero dose corresponding to the natural mutation rate. The effects of radiation seem to vary considerably for different gene loci and our knowledge is at present small and we have little or none for man.

The Committees came to the conclusion that the radiation dose required to double the mutation rate probably lay between 30 and 80 r. A good yardstick for measuring the effect of man-made radiation was the natural radiation dose to which everyone is subjected by the cosmic rays, radium in the ground and potassium in the blood. This gives a dose of 3 rem in thirty years to those who live in England and about 10 per cent more for those living in granite country such as Aberdeen. Dwellers at 10,000 ft. can receive up to 5 rem in thirty years. The Committees suggested that the dose of radiation additional to the natural radiation should be limited to about twice the natural dose—that is, about 6 rem in thirty years. Both Committees feel that too high a contribution to this is already being provided by diagnostic radiology. In Britain, from a sample hospital survey, it appears that this contributes at least 22 per cent of the natural dose. In the United States it was much larger. This is now being inquired into by a committee under Lord Adrian, and it is evident that substantial reductions can be made—indeed, it has happened already in some hospitals.

Other smaller contributions to the population dose are provided by wrist-watches, television sets and from fall-out from atomic weapons. The dose due to fall-out is at present 0·6 per cent of the natural background, mainly due to the ingestion of cæsium-137.

The contribution from the exposure of atomic energy workers in Britain is rather smaller than this. Records are kept of the exposure of all workers in atomic energy establishments, and these show that in the United Kingdom the average dose is 0·25 rem. per annum, so if this level continues it would contribute 7·5 rem in thirty years. Since the population in atomic energy establishments is less than one-thousandth of the total population and only exposure before the age of reproduction is effective genetically, the net contribution to the population is less than 0·1 per cent of the natural dose per annum.

The Medical Research Council Committee discussed another important aspect of fall-out—the ingestion of strontium-90, which reaches human bodies through three steps in the food-chain. Explosions of megaton fission bombs send fission products into the high stratosphere, whence they settle only slowly into the troposphere over a period of five to ten years or more. During this time the strontium-90 decays with a half-life of twenty-eight years. When the activity reaches the troposphere it is washed down by rain. From measurements taken by aircraft, we have some idea of the fission content of the stratosphere. Dr. W. F. Libby has stated that for the past two years it has corresponded to 24 megatons of fission. We also measure the strontium-90 content of rain-water. In this way we can make approximate estimates of the level of soil contamination likely to result. The Medical Research Council report suggested that by 1956 it might increase four-fold over the level at December 1955 from bombs already exploded, and that, should the various types of explosions continue at the rate then current, the accumulated deposits might rise to about fifty times the 1956 level in a hundred years time. The strontium-89 and strontium-90 deposited by rain finds its way to roots and so into the plant, or it may be deposited directly on grass and food crops. Large areas of grass are eaten by cows and so the strontium-90 appears in milk, whence it is transmitted to human bones. For the past three years measurements of the deposition of strontium-90 in soil and herbage, and its concentration in milk and human bones, have been carried out in Britain and the United States and other countries. It is convenient to consider the results in terms of a 'strontium unit'

which is one micromicrocurie per gram of calcium in soil, milk or bone. The cumulative fall-out is rising, but the level in milk has been fairly constant since the middle of 1955 and now ranges from four to ten strontium units, depending on locality. The Medical Research Council Committee report sets a limit of 100 strontium units for concentration in human bones, but said that immediate consideration would have to be given if the level rose to 10 strontium units. They thought this might happen in one or two decades from the bomb explosions already carried out. The present level in Britain is at most 1·5 strontium units, which is still a good way from the 10 strontium unit level.

A good deal of discussion and controversy has recently resulted from a report of a committee of the Atomic Scientists' Association on the hazards introduced by fall-out. The report attempts to calculate the number of bone cancers to be expected from the production of one megaton of fission products. The starting point for this calculation is an estimate of the number of bone cancers produced by 0·1 microcurie of radium, this being the maximum permissible level for radium in the skeleton for occupational workers. The report uses the survey, presented by Hasterlik to the Geneva Conference, of the clinical effects on a number of patients in the Chicago area who were treated with radium injections twenty to thirty years ago. From this the Atomic Scientists' Association Committee calculates that a radium burden of 0·1 microcurie would lead to a 1 : 200 chance of producing a bone cancer. This conclusion is considered by some medical statisticians to be invalid, and indeed, if it were true, the international maximum permissible levels would be far too high.

From this starting point, the Committee computed the number of bone cancers to be expected from the strontium-90 in one megaton of fission products, assuming as a worst possible case that the probability of carcinogenesis is proportional to dose, down to a level 1,000 times less than the maximum permissible level. This assumption is also uncertain. For these reasons I see no point in departing from the conclusions of the Medical Research Council report.

I have spoken so far of the biological hazards of atomic energy development. To give a balanced view, I should look at the other side of the picture and see what are the advantages to the biological sciences gained from these developments. First among these are the results obtained from the new tools of the biologist—radioactive tracers. These are produced in our atomic piles and incorporated into complex organic compounds by our Radiochemical Centre at Amersham. The use of tracer elements has changed in a major way our ideas in metabolic processes. On the old ideas, food was thought of as a fuel to be used for supplying energy or repairing wastage in tissues. It has now been realized that "the large complex molecules in food and in the less complex compounds which form them—the fatty acids, amino-acids and nucleic acids—continually participate in rapid chemical reactions. The fragments of complex molecules so released are mixed with those from other similar molecules, and with those absorbed from the alimentary canal, forming a metabolic reserve. Some of the fatty-acid molecules are completely destroyed ; others of similar structure are continually formed from all kinds of substances, and in particular from carbohydrates. Similar reactions also take place with the decaying products of proteins. Thus the biological system is a vast cycle of closely inter-related chemical reactions" (Geneva Conference Papers).

The research work has also demonstrated the rapid rate of turnover of particular molecules. Thus amino-acids are assembled into proteins in about 25 min. Studies by Hevesy with radioactive iron show that of the 4 milligrams of iron present in human blood plasma, half of it leaves the circulation in about 90 min. Half of this finds its way into the bone marrow to be used for the formation of hæmoglobin in the blood corpuscles, so 16 milligrams a day are used for hæmoglobin formation. The other half finds its way to the liver and other organs. In cases of refractory anæmia the iron atoms disappear less rapidly from the plasma, so studies in anæmia are possible.

Studies using radioactive sodium show that half the sodium in the blood plasma leaves the plasma in one or two minutes. Studies with radiocarbon have shown that even the crystalline structure of the bones is in a stage of flux. It has also been possible to work out the exact metabolic pathways by which important compounds have been made. Thus the origin of every carbon atom in the complex porphyrin molecule has been determined ; the pathways of formation of the blood pigment hæmatin have similarly been unravelled.

The general opinion seems to be that this new knowledge with change of concept was leading to important revisions in the search for the therapy of metabolic diseases. However, only a beginning has been made—mainly by describing the metabolic processes. We are apparently still far from understanding in detail how they work. "It remains for the future to reveal how the new knowledge can be used for the conquest of disease."

Radioactive isotopes are also used as sources of radiation for the treatment of malignant disease. Twenty years ago radium was used in quantities of several grams for radiotherapy in the so-called 'radium bombs' of the time. Radiotherapists now use radiocobalt units a thousand times as strong, using the cobalt-60 produced in nuclear reactors. We can now produce in Britain about 10,000 curies a year, and with our new reactor DIDO we shall be able to increase our annual output by 30,000 curies a year.

Besides their use as an alternative to radium and X-ray sets, radioisotopes have a special value in therapy because of their flexibility in use. Thus radioactive sodium, which emits gamma-rays, has been injected as a solution into the bladder to treat malignancy ; colloidal solutions of radioactive gold-198 or radioactive yttrium are injected into lung tumours because they stay reasonably well located and also decay rapidly with a half-life of a few days.

The use of thulium-170 and xenon-133 has been developed by Prof. W. V. Mayneord and his colleagues. These sources emit gamma-rays of low energy—85 keV. and 81 keV. The sources are easily protected, and since they are virtually point sources they can be used in localities where X-rays would be inapplicable. The human race has a great deal to gain both from the enormous potential increase in its energy resources and from the new tools which have been provided to the biologist. These new powers introduce new hazards. We must study and control these with all the power of the scientific method and so enable these benefits to be safely enjoyed.

OBITUARIES

Dr. Josephine Macalister Brew, C.B.E.

It is hard to believe that Dr. Macalister Brew is dead; for if any one adjective could have described her it would have been the hackneyed word 'vital'. Of her it was abundantly true, for there can have been few people who have lived so fully, so usefully, or so serviceably.

Her last official job was as education and training adviser to the National Association of Mixed Clubs and Girls' Clubs. But that title gives no idea of the immense scope of her interests and activities. She was not a dabbler—to her that word was an insult; she was simply a person of such energy and such catholicity of interest that she left untouched no part of the wide field of the lives of young people. She was not a simple-minded 'do-good-er'. Indeed, her unorthodox methods and rather unusual appearance sometimes frightened, even alarmed, the traditionalists. But she had a remarkable flair for getting inside the skins of the inarticulate young and then assessing what she found by the clear light of charitable reason.

For her intellectual equipment was of a quality quite unusual. She had a robust contempt for the 'starry-eyed' and the 'stuffy' (her own words); she quite simply hated the pompous and the pretentious; and for young people she had a boundless but shrewdly discriminating affection.

It was not surprising that she was worked to death. Government departments, charitable trusts, bodies as varied as the Marriage Guidance Council and the Educational Drama Association all made demands on her strength; and to none of them did she give half-measure. What she enjoyed most was not sitting around a committee table but gossiping with boys and girls in a canteen or a 'pub.', and there must be scores of them who remember this odd little figure who knew what they were thinking before they did and, more, could put it into intelligible words.

Josephine Brew made rather shop-soiled words like 'social welfare' or 'youth service' come to life. She never forgot the eternal importance of each single individual human being, and she would never allow generalizations or abstractions to hide the individual boy or girl, puzzled, uncertain, bewildered or lost. She had learning, and in her own field success—the award of a C.B.E. in the Birthday Honours only underlines the melancholy coincidence of her death—and the affection of a multitude of friends. She would prefer to be remembered as one who never lost her astringent affection for hundreds of 'crazy mixed-up kids'. John Wolfenden

Dr. J. E. Hamilton, I.S.O.

James Erik Hamilton, who died suddenly at Stanley, Falkland Islands, on April 15, a few weeks before his sixty-sixth birthday, had spent more than thirty years in the Falkland Islands and their Dependencies. After graduating at the University of Liverpool in 1913, he spent the summers of 1913 and 1914 at Blacksod Bay, Co. Mayo, on behalf of the Committee of the British Association appointed to investigate the biological problems incidental to the Belmullet whaling station. In 1914 he took his M.Sc. degree, specializing in oceanography, and occupied junior teaching posts at King's College, London, and The Queen's University, Belfast, until 1916, when he joined the R.A.M.C. as bacteriologist. In 1919 he was appointed to be Government naturalist and magistrate in the Falkland Islands, a post he occupied for thirty years until his retirement in 1949. For half this period, from 1924 until 1939, he was seconded to the scientific staff of the Discovery Investigations, and served in the ships belonging to the Discovery Committee, in the Marine Station at South Georgia, and in England. During the Second World War he was in the Falkland Islands and acted as registrar general and registrar of the Supreme Court, as well as being a police magistrate at Stanley and a temporary member of the Legislative Council. He was awarded the Polar Medal in 1943, and appointed a Companion of the Imperial Service Order in 1948.

Hamilton was a good field naturalist and was particularly interested in marine mammals and birds, on which he published a number of papers in various scientific journals. His most important published work is contained in two papers on the southern sea lion that appeared in Discovery Reports in 1934 and 1939, and formed the main part of the material for which his doctorate was conferred. During his residence in the Dependencies he had the opportunity for collecting much rare cetacean material and enriched the collections of the British Museum (Natural History) by presenting many valuable skulls and skeletons of the southern dolphins, which are generally very poorly represented in museum collections. In addition, he sent home large collections of skulls from several species of southern seals, specimens which are of unusual value as they are accompanied by very full data. After his retirement in 1949 Hamilton continued to reside in the Falkland Islands, where he carried on with his collecting and zoological work. He was particularly concerned for the preservation of the stocks of whales, which he considered were being dangerously over-fished, and stated his views in several outspoken contributions in *Nature* during recent years.

Hamilton was of medium height and stocky build, and enjoyed the rough conditions of life that he experienced on many of his expeditions in the course of the Discovery investigations, as well as during his work as Government naturalist. The latter took him into some very remote places in company with the sealers and whalers, among whom he had many friends. In 1931 he married Miss Rose Purdie, who survives him, and to whom we extend our sympathy.

L. Harrison Matthews

Dr. J. F. Allan

Dr. J. F. Allan, superintendent of the Ship Division, National Physical Laboratory, collapsed and died on June 8 while sailing on holiday at Aldeburgh, Suffolk.

James Foggo Allan was born on July 23, 1904, at Brechin, Angus, the son of a Church of Scotland minister. He was educated at Dumbarton Academy and the University of Glasgow, and served an apprenticeship with William Denny and Bros., Ltd., the

Dumbarton shipbuilders. He held the Sir William White Research Scholarship of the Institution of Naval Architects during 1927–29. In 1948, he was awarded the degree of D.Sc. by the University of Glasgow for his pioneer work in the development of ship roll stabilizers, now a familiar feature of many passenger ships.

From 1926 until 1948 he was on the staff of the ship model experiment tank at Dumbarton; during the last six years of this period he was in charge of the department. In 1948, he was appointed superintendent of the Ship Division of the National Physical Laboratory.

Since Dr. Allan's appointment, the Division has considerably widened its range of activities and, under his enthusiastic guidance, the new National Physical Laboratory Ship Hydrodynamics Laboratory at Feltham was planned and construction begun. In this Laboratory the work of the Division in carrying out experiments for ship-builders on new designs and in basic research into the hydrodynamic problems of ships will be continued in the ways in which he so firmly believed.

Dr. Allan was an international figure in the world of naval architecture; he served on many committees and published a number of notable papers. He was a member of Council of the Institution of Naval Architects and of the Scholarships and Publications Committee. He took a leading part in the organization of the triennial International Towing Tank Conference (formerly International Conference of Ship Tank Superintendents), serving on the Conference Standing Committee, and was an active member of several British Shipbuilding Research Association technical committees, acting as chairman of the Propulsion Sub-Committee. The papers which Dr. Allan published dealt with many different ship design problems, including scale effects on propellers and shaft supports, the resistance of barges, hull forms for drifters, and the comparison of ship-trial results with model predictions. His paper on "The Stabilization of Ships by Activated Fins" was awarded a premium of the Institution of Naval Architects in 1945, and that dealing with "The Effect of Roughness on Ship Resistance", which he presented jointly with Mr. R. S. Cutland to the North East Coast Institution of Engineers and Shipbuilders last year, gained the M. C. James Medal.

In addition to the work described in these papers, Dr. Allan was actively engaged during the Second World War on the development of a high-speed hydrofoil-supported torpedo boat, and at the time of his death was vigorously developing new ship features. His loss will be keenly felt, not only at the National Physical Laboratory but also in shipbuilding circles throughout the world. It is particularly tragic that his services will not be available at the time when the new ship research laboratory, one of the most comprehensive in the world, is to be put into operation.

NEWS and VIEWS

Royal Society of Edinburgh: New Fellows

THE following have been elected Honorary Fellows of the Royal Society of Edinburgh: Dr. H. J. Bhabha, chairman, Atomic Energy Commission of India, Bombay; Sir Alexander Fleck, director, Imperial Chemical Industries, Ltd.; Dr. R. J. Heim, director, Museum of Natural History, Paris; Prof. Olaf Holtedahl, professor of historical geology in the University of Oslo; Sir Rudolph Peters, professor emeritus of biochemistry in the University of Oxford; Prof. C. E. Tilley, professor of mineralogy and petrology in the University of Cambridge.

Mathematics in the University of Manchester: Prof. G. J. Kynch

PROF. GEORGE JAMES KYNCH, at present professor of applied mathematics in the University College of Wales, Aberystwyth (see *Nature*, 169, 266; 1952), has been appointed to the new chair in mathematics in the faculty of technology in the University of Manchester. Prof. Kynch graduated at the Imperial College of Science and Technology with honours in physics in 1935. He then read for honours in mathematics and obtained a first-class degree in the following year, together with a University prize and research scholarship. He obtained the Ph.D. and the diploma of the Imperial College in mathematics in 1939. His research on valence theory and magnetism at the Imperial College during 1936–40 was under the direction of Dr. (now Sir) William Penney. Dr. Kynch was appointed to a lectureship at the University of Birmingham under Prof. R. E. Peierls, and also undertook part-time research as a member of the Ministry of Supply "Tube Alloys" team at the University of Birmingham. Since 1952 he has been professor of applied mathematics in the University College of Wales, Aberystwyth. Prof. Kynch will take up his duties at Manchester in September.

Chemistry at Auckland University College: Prof. D. R. Llewellyn

DR. D. R. LLEWELLYN, who has recently been appointed professor of chemistry at Auckland University College, New Zealand, graduated with first-class honours in chemistry from the University of Birmingham in 1941. During 1941–44 he carried out research under the direction of the late Prof. F. Simon at Oxford, where he obtained the D.Phil. degree, and in the following year he went as a research assistant in the Cavendish Laboratory, Cambridge. His university teaching work on a full-time basis started in the University College of North Wales in 1945, when Prof. E. D. Hughes held the chair of chemistry at Bangor. Llewellyn was a lecturer there until 1949, when he was appointed to an Imperial Chemical Industries fellowship, tenable at University College, London, where he became a lecturer in 1952.

Dr. Llewellyn's published work has dealt with the chemistry of uranium, the preparation of stable isotopes by fractional distillation, and the use of various tracers in the study of the mechanism of reactions. In 1952, he was awarded the Weizmann Prize for a paper on the separation of isotopes, published in collaboration with Drs. I. Dostrovsky and J. Gillis. He has shown marked ingenuity in the design and construction of physical apparatus, especially large-scale distillation columns of high efficiency. His natural aptitude in this direction was, no doubt, fostered when he worked as a physical

chemist in the schools of physics of Oxford and Cambridge, and it is now a very highly developed part of his equipment. His work is characterized also by great versatility in the use of isotopes, particularly in the elucidation of the course of chemical reactions in the inorganic, organic and biochemical fields. These activities are well integrated, and they will be brought to bear most effectively in his new post as professor of chemistry and director of the Laboratories at Auckland University College.

British Museum (Natural History): The Neolithic Revolution

In the Central Hall of the British Museum (Natural History) in South Kensington the series of displays illustrating the evolution of man and his culture has been extended by the arrangement in Bay 4 of a new exhibit on the "Neolithic Revolution". The exhibit deals primarily with the biological foundations of Neolithic culture: Panel 1 with the beginnings of plant cultivation; Panel 2 with the domestication of animals (dogs, goats, sheep, cattle and pigs); Panels 3 and 4 with related activities, including hunting and fishing with the aid of new devices, the mining of flint, the manufacture and trading of polished stone axeheads, their use in the clearance of forest for agriculture, the construction of permanent dwellings, the formation of villages, and the development of specialized crafts such as basketry, the making of pottery, and the spinning and weaving of plant and animal fibres for use in clothing. The probable relation of Neolithic religious ideas to agriculture is indicated. Specimens shown on the panels have been drawn from a wide range of Neolithic sites, including Jericho, Jarmo (Iraq), and others in Egypt, Sudan, Switzerland, Denmark and Britain—notably Windmill Hill (Wiltshire), Maiden Castle (Dorset), Church Hill, Findon (Sussex), and Grimes Graves (Norfolk). The first panel includes examples of some of the earliest cultivated plants (einkorn and emmer wheat, flax and the Celtic bean) recently grown under Neolithic conditions on a private experimental plot in Kew Gardens. The exhibit demonstrates some of the contributions of the natural sciences (particularly botany, zoology and geology) to archæology; and it indicates the biological interest of many of the findings of archæological research.

James Sowerby (1757–1822)

Another new exhibit has also been arranged in Bay 4 of the Central Hall of the British Museum (Natural History) to commemorate the work of James Sowerby, the founder of a family whose members have been distinguished as authors and illustrators of natural history works, and who between them wrote and illustrated more than seventy works on botany, zoology and palæontology. James Sowerby, born in 1757, studied with the marine painter, Richard Wright, and was later employed by William Curtis to make drawings for the *Flora Londinensis* and the *Botanical Magazine*. Sowerby, however, is probably best known for his plates to the "English Botany" (1790–1814), the text of which was written by Sir J. E. Smith, though the work is generally referred to as "Sowerby's English Botany". Sowerby was also deeply interested in mineralogy, and his "Mineral Conchology of Great Britain" (1812–46) is a work of considerable historical interest. An unfinished zoological work, "The British Miscellany" (1804–6), contains as its first plate a figure of 'Sowerby's Whale', described and figured by the artist from a specimen found near Elgin in Scotland. The Museum possesses the original water-colour drawings for the "English Botany", more than 2,500 in number, the originals of the "English Fungi" (1795–1815), and the drawings to illustrate J. Dickson's "Fasciculus Plantarum Cryptogamicarum Britanniae", Fasc. 2–4 (? 1789–1801). A selection of these, together with some of Sowerby's published works, are on exhibition, and give some indication of the great talent and wide scientific interests of this famous artist-naturalist.

Illinois Journal of Mathematics

The pressure on scientific periodicals is still so great that new journals are bound to be welcome, except possibly to those librarians to whom space is already a problem. The new *Illinois Journal of Mathematics*, published by the University of Illinois, Urbana, has a strong editorial board consisting of R. Baer (Frankfurt-am-Main), J. L. Doob and A. H. Taub (University of Illinois), G. W. Whitehead (Massachusetts Institute of Technology) and O. Zariski (Harvard). It will publish research papers in pure and applied mathematics, written in English, French, German or Italian. A volume of four quarterly parts will cost 9 dollars, but there is a reduced subscription available to members of the American Mathematical Society. The first part (March 1957) contains ten papers in its 114 pages; most of these are fairly short, with an algebraic and topological flavour, but there is a first instalment (50 pages) of a three-part memoir on Markoff processes and potentials. It will be of interest to see whether the new journal can attract good work on applied as well as on pure mathematics.

British Birds

Early in 1907 H. F. Wetherby persuaded a number of friends and ornithologists to support a monthly magazine devoted entirely to the study of British birds. The fiftieth anniversary of *British Birds* is now being celebrated, and its latest issue (**50**, No. 6; June 1957) tells the story of its steady rise in influence and quality until, as the messages from many countries indicate, the journal is now recognized throughout the world as an outstanding contribution to ornithological literature. Greetings which must give particular pleasure to the editors include that from Tom Harrisson, curator of the Sarawak Museum, and Prof. G. P. Dementiev, of the University of Moscow, a confessed admirer of *British Birds* for thirty years. The journal has always been noted for the quality of its plates, and this birthday issue contains a reproduction of a painting of collared doves (*Streptopelia decaocto*) by R. A. Richardson which is worthy of its predecessors; so, too, are some photographs by, among others, Eric Hosking, James Alder and J. H. Drenth. *British Birds* is to be congratulated on its first half-century of existence; and may look forward to the second half-century with confidence.

Zoological Libraries

Zoological libraries are the subject of the sixth in the series of publications on Library Resources in the Greater London Area, issued by the Library Association (pp. ii+21. London, 1957. 4*s*. 6*d*.). Compiled by A. C. Townsend and G. B. Stratton, the pamphlet deals chiefly with the British Museum

(Natural History), the libraries of the Zoological Society of London, of the Commonwealth Institute of Entomology, the Linnean Society of London, the Royal Entomological Society and the Horniman Museum and Library, though there is a brief note on other sources also, such as the holdings of the Science Museum Library and the Patent Office Library. The British Museum (Natural History) Library, which probably contains the largest collection of zoological books and periodicals in Britain, is described in some detail by Mr. Townsend and that of the Zoological Society by Mr. Stratton. The authors are to be congratulated on a most useful guide to sources of zoological literature, the value of which is enhanced both by the inclusion of references to other accounts of particular libraries and to the main bibliographies of zoology. There is an index to persons, institutions and serials.

Christian Faith and the Freedom of Science

Dr. R. Hooykaas, professor of the history of science at the Free University, Amsterdam, is the author of a recent pamphlet on "Christian Faith and the Freedom of Science" (Philosophia Libera. Pp. 24. London: The Tyndale Press, 1957. Published for the Research Scientists' Christian Fellowship. 1*s.* 6*d.*), in which he points out that science is stifled whenever men cherish preconceived ideas which they refuse to submit to test, whether under totalitarianism, secular or clerical, or whenever a well-meaning piety exalts secondary standards of authority to a place that belongs only to God. Prof. Hooykaas contends that Scripture, rightly approached, liberates the mind from all these constraints. Reviewing the several threats to the freedom of science, he cites Calvin as an example of a man made free from traditional beliefs and unhampered by an elaborate theory of inspiration. He argues that confidence in the possibilities of science and in the freedom of thought, as well as self-restriction in theorizing and obedience to the dictates of Nature, are the necessary consequences of a truly liberal religion, and illustrates his argument by a brief historical survey of relations between science and religion in the Middle Ages, in the Reformation period and in the seventeenth century. The Puritan scientists of the seventeenth century regarded science as an ally of true religion, and Prof. Hooykaas points out that the educational ideals of the Enlightenment and those of the English Puritans were almost the same, the Enlightenment being considered as a secularized puritanism. The spirit of the Reformation and the spirit of science have much in common.

Electronic Image Devices in Microscopy

Reports on the use of electronic image converters, television cameras and flying-spot scanning systems in microscopy have appeared from time to time; but it cannot be said that these methods have been responsible for any spectacular advances. Their theoretical possibilities are considerable, but as yet the practical results have been disappointing. Despite the high cost and complexity of the apparatus, electronic 'noise' and other imperfections usually reduce the image quality to below that obtainable by simple visual or photographic methods. A very attractive feature is the possibility of image intensification, that is, the ability to present a bright picture on a screen even though the object itself may be very weakly illuminated. This is most important in ultra-violet microscopy, since ultra-violet light damages living cells. A remarkable ultra-violet colour-translating television microscopy has recently been developed at the Rockefeller Institute, New York, by V. K. Zworykin, F. L. Hatke and C. Berkley. The instrument recalls the earlier photographic one described by E. H. Land and his collaborators (*Science*, 109, 371; 1949), in which the specimen was illuminated in turn by three monochromatic bands of ultra-violet light, and three photographic negatives were made. After processing at high speed in a special machine, these negatives were projected simultaneously through red, green and blue filters on to a viewing screen. In this way differences in ultra-violet spectral absorption were 'translated' into differences in visible colour. It was claimed that by a proper selection of illuminating wave-lengths colour differences could be related to variations in chemical composition, particularly with regard to proteins and nucleic acids. The new system eliminates photography by employing a closed-circuit colour television receiver, so that its action is virtually instantaneous and it is possible to view cells in motion. No results of any biological importance have yet been reported with the original colour-translating microscope, and it remains to be seen whether the new instrument will turn out to be simply another brilliant technological achievement. Nevertheless, there is little doubt that the next generation of microscopists will use electronic devices almost as freely as photography is used to-day, and this pioneer work must be followed with cautious and sympathetic interest.

Geological Resources of Britain

At a meeting of the Parliamentary and Scientific Committee on May 14, a discussion on British geological resources was opened by Sir William Pugh, director of the Geological Survey and Museum, who described the work of the Geological Survey of Great Britain in relation to supplies of coal, iron ore and water. He stressed the dependence of development and exploitation of these and other natural resources on the up-to-date, large-scale geological maps and memoirs which it is the primary function of the Geological Survey to provide. Mr. P. T. Cox, of the British Petroleum Co., Ltd., who spoke next, dealt with the oil resources of Britain, and particularly the results of recent prospecting, which, at present, is concentrated principally in the Eakring area of Nottinghamshire, where the ultimate production of some 10 million tons is probably the limit. Mr. H. E. Collins, of the National Coal Board, paid tribute to the help of the Geological Survey in the Board's drilling programme. This programme had already provided resources estimated at more than 4,000 million tons through the construction of fifteen new collieries and the reconstruction of some 200 existing collieries. Sir Arnold Waters dealt with problems of water supply, ironstone, and sand and gravel supplies, pointing out that the demand for sand and gravel had already considerably exceeded the expectations of the Advisory Committee. In the discussion that followed, Mr. Collins said that there are sufficient proved coal resources for current development, and further proving would continue around the fringes of coalfields now being exploited. Sir Arnold Waters said that improved land drainage and the great impermeable urban areas were affecting the average rate at which water reaches the under-

ground water-tables. Many areas, including London, are over water-tables which are known to be dropping, but London depends only in part on its underground supplies. Overground supplies have been developed, because the rate of consumption from underground supplies has exceeded the available quantities of water. Sir William Pugh said that a deep borehole drilled at Burford by the Geological Survey entered Upper Coal Measures at about 1,100 ft., and they were proved to a thickness of 2,660 ft. It is not known whether they are underlain by productive Coal Measures because the borehole was stopped by technical difficulties at 3,767 ft. Within the comparatively small confines of the British Isles there is a remarkable range of phenomena of geological interest and of materials of economic importance.

Florigenic Hormone in the Strawberry

C. Sironval has given a comprehensive account of observations and experiments on the inception of flowering in an ever-flowering strain of strawberry, *Fragaria vesca* L. var. *semperflorens* Duch. (C.R. de Recherches, Trav. du Centre de Recherches des Hormones Végétales, No. 18, 9–229, Feb. 1957, Bruxelles). The author has found that during the course of development from the seed, the initial vegetative phase is followed by a second distinctive physiological phase, designated as the *photophase*. During this phase, the conditions essential for the onset of flowering are long days and a fluctuating daily temperature—warm days and cold nights. This period of development can be distinguished by characteristic features in leaf morphology and coloration. Once induced, the flowering phase persists until the death of the plant. The characteristic development of the photophase is immediately arrested by exposure to short days. Sironval's experimental observations indicate clearly that the photophase is the period when the specific transformations which prepare the way for flowering take place. In particular, he has directed attention to the fact that changes in the metabolism of the chlorophylls are especially distinctive during this phase. During exposure to long days he finds that there is a relative lowering of the amount of chlorophyll *b*. The accumulated evidence is held to be indicative of a correlation between the chlorophyll metabolism, environmental conditions—in particular, the day-length—and the inception of flowering. When a crude extract of the unsaponifiable fraction of leaves from flowering strawberry plants—and here particular interest may attach to vitamin E (in low concentrations) and a sterol (in high concentrations)—was applied to the meristems of plants not yet in the flowering phase, cell division was activated in the axial region of the meristem, this being characteristic of the transition to the flowering state.

Australian Biochemical Society

The Australian Biochemical Society was founded at the time of the meeting of the Australian and New Zealand Association for the Advancement of Science in Melbourne in August 1955. At that meeting Dr. M. R. Lemberg was elected as the first president, and a constitution was adopted. The first annual conference was held in Sydney in May 1956 and the second annual conference was held in Melbourne during June 5–7. At this latter meeting fifty-seven papers were presented, and abstracts of these papers will be published in the *Australian Journal of Science*. The present president is Prof. V. M. Trikojus, Department of Biochemistry, University of Melbourne, and the hon. secretary is Dr. F. D. Collins, Department of Biochemistry, Australian National University.

Announcements

Dr. Å. Vedel Tåning, director of the Danish Fisheries and Oceanographic Research Institute, has been elected an honorary member of the Marine Biological Association of the United Kingdom.

The following have recently been elected to office in the Institution of Electrical Engineers for the session 1957–58: *President*, T. E. Goldup; *Vice-Presidents*, S. E. Goodall, Dr. Willis Jackson, G. S. C. Lucas, Sir Hamish D. MacLaren, C. T. Melling; *Honorary Treasurer*, Viscount Falmouth.

The recently published Yearbook of Forest Products Statistics, 1956 (pp. vi+170. Rome: Food and Agriculture Organization of the United Nations; London: H.M. Stationery Office, 1956. 12*s.* 6*d.*; 2.50 dollars), is the tenth issue of this report, covering details of world forestry output, trade and consumption compiled from information supplied by more than 120 countries throughout the world.

A "Joining of Metals" conference on "The Wetting and Spreading of Liquid Metals on Solid Metal Surfaces", organized by the Department of Industrial Metallurgy in the University of Birmingham, is to be held at the University of Birmingham on September 25. Further details and enrolment forms can be obtained from the Secretary to the Department.

A series of eight lectures on operational research and cybernetics in industry has been arranged by the Department of Operational Research and Cybernetics of the United Steel Companies, Ltd., in co-operation with Dr. G. Lawton, principal of the Sheffield College of Commerce and Technology, to be presented during October and November on Wednesdays from 2.30 to 4 p.m. The course is addressed to senior management, and is likely to be followed in 1958 by a longer and more detailed course addressed to practitioners who may be appointed to carry out this type of work. The course will be introduced by R. S. Gander, development manager in the Department of Operational Research and Cybernetics, and the later lectures, also delivered by members of the Department, will be on "Queues", by K. D. Tocher, research manager; "Operational Research Models", by R. S. Gander; "Operational Research Machines", by D. G. Owen, computer applications manager; "Processes involving Chance", by K. D. Tocher; "Information", by P. G. Lucas, operations manager; "Production Control" and "Cybernetics", by Stafford Beer, head of the Department. Further details can be obtained from the College of Technology, Sheffield, 1, or the Department of Operational Research and Cybernetics of the United Steel Companies, Ltd.

Addendum. The symposium on "Microchemistry", to be held at the University of Birmingham under the auspices of the Society for Analytical Chemistry, and announced in *Nature* of June 29 (179, 1337; 1957), will take place during August 20–27, 1958.

INITIATION AND GROWTH OF EXPLOSION IN SOLIDS

A CONSIDERABLE amount of work has been carried out in recent years on slow and fast reactions in solids, and in particular on explosive solids. In order to bring this work together and to review the present position of this field of research, a discussion arranged by Dr. F. P. Bowden for the Royal Society was held on May 30 in the Society's rooms at Burlington House. The discussion was international in character, and there were contributors and visitors from Australia, Belgium, France, Great Britain, Sweden, Switzerland, the United States and the U.S.S.R. The programme was an ambitious one, and by concentrating only on essential points and the more recent advances, it was possible to fit in twenty-two prepared papers. The discussion on these papers was lively and valuable, and many new points were brought out at this stage. There was some time for informal discussion. The papers and the discussion will be published in the *Proceedings of the Royal Society*.

The discussion fell into two parts. The first, on the initiation of explosion, included some work on the slow decomposition of a number of explosive materials. The second part dealt with the growth of reaction to explosion, and with low-velocity detonation. The process of high-velocity detonation was not considered since this had been dealt with in a discussion in 1951 organized by Sir William Penney.

In opening the discussion, Dr. F. P. Bowden summarized the different ways in which reactions in solids may be initiated. These are: (1) by heat which raises the material to the ignition temperature; (2) by shock; this can act by (*a*) an adiabatic heating of compressed gas spaces; (*b*) a frictional hot spot on the confining surface or on a grit particle; (*c*) intercrystalline friction of the explosive itself; (*d*) viscous heating of the explosive at high rates of shear; (*e*) heating of a sharp point when it is deformed plastically; (*f*) mutual reinforcement of gentle shock waves; (3) by ultrasonic vibrations; (4) by electrons, α-particles, neutrons and fission fragments; (5) by light of sufficient intensity; (6) by electric discharge; (7) by 'spontaneous' ignition of a growing crystal.

Dr. Bowden emphasized the importance of using modern physical methods to follow reactions in solids. The combined use of electron diffraction and electron microscopy by Dr. J. Sawkill has shown that it is possible to follow the collapse of the lattice during decomposition in materials such as silver azide to give the final product silver. With the aid of the scanning electron microscope, J. A. McAuslan has also followed the early stages in the decomposition of silver azide. There is evidence that reaction can occur preferentially not only on the surface of the crystal but also at defects within it. This leads to a cracking and splitting of the crystals along preferred directions. This break-up has also been observed by S. K. Deb in his experiments on the decomposition of P.E.T.N. crystals by a light flash. The disintegration of crystals into small blocklets, which may be about 10^{-5} cm. across, is important both in the early phase and also, as shown by Evans and Yoffe, in the growth of burning to detonation.

Some puzzling observations made by G. T. Rogers on spontaneous explosions were also discussed. During the growth of crystals of β-lead azide and mercuric azide in solution, an explosion may take place for no apparent reason. Dr. J. V. R. Kaufman (United States) said that α-lead azide also explodes spontaneously during the initial stages of growth in solution. There is at present no adequate explanation for these observations, although some suggestions have been put forward. Dr. Z. V. Harvalik (United States) thought that the heat of aggregation of small crystals could be an important factor.

Thermal decomposition and explosion. The growth of explosion from the point of initiation is a critical process. If the size of the nucleus of decomposition or 'hot spot' is greater than about 10^{-3} cm. in diameter, then for a number of explosive materials there is a chance that the reaction will grow to explosion. Thermal factors determine this growth, and it is necessary for the rate of heat liberation to be greater than the rate of heat loss. Two problems in thermal explosion theory were analysed by Dr. G. B. Cook. The first was concerned with a slab of solid explosive, where one face is placed in contact with a constant-temperature bath. From his calculations, he obtained a relation between ignition time and the temperature of the bath and the initial temperature of the explosive. The interesting point that emerges is that for a given initial temperature the order of thermal sensitivity can change with the bath temperature. The examples given by Dr. Cook are 'Tetryl', P.E.T.N. and R.D.X.

A paper on the thermal decomposition of silver azide by Drs. B. E. Bartlett, F. C. Tompkins and D. A. Young was read by Dr. F. C. Tompkins. The decomposition was followed both above and below the crystallographic transformation at 190° C. Dr. Tompkins stressed the importance of the interfacial reaction at the product–reactant interface. Activation energies for the reaction were given. Below 190° C. this is 44 kcal./mole and above that point it is 31 kcal./mole. These authors also presented some results on the ionic and photoconductance of silver azide.

Initiation by shock. Three papers were presented on the ignition of explosive materials by the compression of gas spaces. Dr. C. H. Johansson (Sweden) considered the case of liquid materials. He showed that in a number of cases a foam is produced during impact. This means that the disintegration of the liquid into tiny droplets is important. He also discussed other experiments on the initiation of explosion in liquids.

To obtain accurate values for the energy required to ignite a number of sensitive materials, Dr. G. J. Bryan and Dr. E. C. Noonan (United States) and J. I. Evans and Dr. A. M. Yuill (Ardeer) have constructed compression apparatus of advanced design. With this apparatus it is possible to vary the compression ratio and the time of compression, and it is also possible to record the light from the burning explosive by means of a photomultiplier. In the apparatus described by Dr. Noonan the gas pressure could also be read as a function of time.

Prof. K. K. Andreev (U.S.S.R.) in a paper entitled "Some Considerations on the Mechanism of Initiation of Detonation in Explosives" gave a résumé of his own and other Russian work. He also emphasized the importance of the disintegration of the solids. In

particular, he considers that the initiation of detonation is due mainly to the sudden rise in pressure when a suspension of the solid explosive which is formed in the gaseous products of burning explodes. He also discussed Landau's ideas on the effects of turbulence at the burning front of liquids and the mechanism by which suspensions might be formed. The work discussed by Prof. Andreev is relevant both to the initiation of explosion and to the growth mechanism to detonation.

Structure and stability of inorganic azides. The marked difference in the decomposition behaviour of materials such as potassium azide and silver azide has led B. L. Evans to attempt to correlate the explosive sensitivity of these compounds with their crystal structure. He considered the azides and the isoelectronic cyanates, thiocyanates and fulminates. Thus in the case of azides the important factor to consider is the ionization potential of the metal compared with the electron affinity of the azide radical. This determines both the extent to which the valence electron is under the influence of the metal and the unit cell dimensions of the metallic azide. From the results that are available, Evans concludes that the explosive sensitivity is dependent on the ionization potential of the metal forming the azide. The ionization potential of the metal will also determine some of the physical properties such as the melting point, and it can be used to interpret results on photoconduction, thermal decomposition and photochemical decomposition.

Initiation by light. Prof. J. Eggert and his colleagues (Switzerland) found some time ago that a number of sensitive materials could be ignited by a light flash of sufficient intensity. In presenting the Cambridge work, J. A. McAuslan discussed his own experiments on the ignition of lead styphnate, and that of G. T. Rogers on silver azide. A thermal mechanism has been postulated for the initiation of explosion, in which the absorbed light energy is converted into heat in a very thin layer near the surface. In the case of silver azide, however, this assumption has been questioned by B. L. Evans. His results on sensitized ignitions suggest that the primary action of the light is photochemical, but that propagation of reaction is thermal. A necessary condition for this growth to explosion is the formation of a molten layer on the surface. It is in the molten state that there is sufficient mobility of the azide radicals to give rise to explosive reaction.

Dr. A. C. McLaren and Dr. G. T. Rogers described their results on the absorption spectra (visible light and ultra-violet) and photoconduction of single crystals of silver azide. They explained their results on absorption spectra in terms of the formation of excitons. The photocurrent is due to the dissociation of these excitons into free electrons and positive holes. These results support the suggestion, made earlier, that during the ignition of silver azide by light the initiation is photochemical in nature.

There was a vigorous discussion of the work presented in these last two sections. In this discussion Dr. J. W. Mitchell outlined his views on the action of metal particles as electron-traps in silver azide. Dr. P. Gray gave his views on the use of enthalpies of formation in describing the behaviour of azides.

Decomposition and explosion by ionizing radiations. The slow decomposition of a number of materials by X-rays was considered by Dr. J. V. R. Kaufman (United States) and by Dr. J. M. Groocock. The only material which explodes during irradiation is nitrogen iodide. This was discussed by Dr. F. P. Bowden. In particular, he showed how McLaren's results on the explosion of nitrogen iodide by α-particles could be shown to be the result of the removal of ammonia from the surface of the nitrogen iodide by the α-particles. Dr. Bowden also discussed some recent experiments by Deb, Evans and Yoffe on the use of the radioisotope of silver as a means of introducing cadmium into crystals of silver azide.

The growth of explosion formed the subject of the second part of the discussion. An introductory paper by Dr. A. D. Yoffe on the work in Cambridge showed that the stages following on initiation of reaction are: (1) growth of reaction to an accelerating burning; (2) transition from burning to low-velocity detonation; (3) propagation of low-velocity detonation. Very little is known about stage (2). The growth of reaction to burning depends on thermal factors. The differences in behaviour of azides and the more complex materials during this stage can be explained in terms of the differences in the possible modes of decomposition of these materials.

There is no adequate theory to explain the propagation of low-velocity detonation in solids. Factors such as the compression of trapped gas, intercrystalline friction and break-up of the solid ahead of the flame front are important. They do not, however, explain all the results that are available. For example, Deb has found that a low-velocity detonation can be propagated through a single crystal of P.E.T.N. containing no obvious air pockets. The formation of a molten or of a vaporized layer is probably important in the growth to explosion and in the setting up of low-velocity detonation.

High-speed photographic techniques were used by Dr. G. P. Cachia and Dr. E. G. Whitbread, by Prof. M. A. Cook (United States), and by Dr. C. W. Lampson and Dr. R. J. Eichelberger (United States) to follow the sympathetic detonation of solid explosives by shocks propagated across an air-gap or through a metal strip. Detonation in the receptor charge does not always occur at the surface in contact with the metal wafer, but initiation may occur within the body of the receptor. A ciné-film, prepared at the Aberdeen Proving Ground, United States, illustrated this effect. This film was remarkable for its clarity and showed a high degree of technical competence. It was much appreciated by all present.

The detonation of pentolite in water by a remote spherical primer was discussed by Dr. C. H. Winning. Other papers presented were: studies on the oxidation induced by ultrasonic radiation on a solid system of lauryl aldehyde and potassium chlorate by Dr. F. A. H. Rice and Dr. D. Levine (United States); the ignition of primary explosives by electric discharges by Drs. R. M. H. Wyatt, P. W. J. Moore, G. K. Adams and J. F. Summer; some kinetic problems of fast reactions by Dr. R. B. Parlin and Prof. H. Eyring (United States); and lamellar twinning and decomposition in potassium azide and sodium azide by Dr. R. W. Dreyfuss and Dr. P. W. Levy.

This discussion has shown that a good deal is known about the initiation of explosion in solids. In his summing up, Dr. F. P. Bowden said there is sufficient data now available for us to argue about the electronic structure and possible modes of decomposition of a number of materials. There are, however, a number of outstanding problems. We know very little about radiation damage in solid explosives. There is also the question of spontaneous explosions

in solids. So far as the growth of explosion is concerned we need more experimental results. In particular, there is even a lack of data of quantities such as thermal conductivity and specific heat. The disintegration and break-up of solids ahead of the reaction zone have been stressed by a number of workers. The formation of a molten zone and its importance, both in the growth of explosion and in low-velocity detonation, have been mentioned. With the development of new apparatus, and with the techniques now available, we may expect a rapid advance in the near future on this problem of the growth of reaction to detonation.

A. D. YOFFE

RECENT ADVANCES IN HIGH POLYMER PHYSICS

A CONFERENCE on "Rheology of Elastomers" was held by the British Society of Rheology during May 29–31 at the British Rubber Producers' Research Association, Welwyn Garden City.

Equilibrium properties of rubberlike materials. In an introductory talk, Dr. L. R. G. Treloar (British Rayon Research Association) said that in the main the properties of rubber and of other polymeric materials in the highly elastic or 'rubberlike' state are now well understood. The stress and birefringence of rubber subjected to different types of finite strain at various temperatures are described to a good first approximation by the 'kinetic theory', a relatively simple molecular theory which treats of the changes of configurational entropy and molecular orientation in a deforming network composed of flexible long-chain molecules. Reviewing the shortcomings of the theory (in the Gaussian approximation), Dr. Treloar said that for simple elongations in the range 150–500 per cent, the discrepancies between the theoretical and observed stress–strain relations have so far not received satisfactory 'molecular' explanation.

A crucial test of the applicability of the kinetic theory to polymeric materials is furnished by the prediction that the rigidity modulus should increase linearly with the absolute temperature and with the concentration of junctions in the network. By using gelatin gels specially prepared to give junctions which are substantially unaffected by temperature changes, P. R. Saunders and A. G. Ward (British Gelatine and Glue Research Association) found that the rigidity modulus did increase linearly with temperature in the range 0°–60° C. and at a rate comparable with that required by the theory. Data both from gel rigidities and from dilute solution viscosities at different *p*H indicated that differences in the rigidities of ordinary gelatin gels must be attributed to differences in concentration and strength of network junctions, rather than to differences in molecular chain 'stiffness'.

Improved techniques for conditioning filaments of natural rubber so as to yield a more accurate attainment of thermodynamic equilibrium (required for comparison with the kinetic theory) were described by P. Thirion (Institut Français du Caoutchouc). For filaments held at constant extension in the range 0–30 per cent, reversibility of tension–temperature cycles (20°–60° C.) was attained to within 0·05 per cent. A new derivation was given of Gee's formula for determining the coefficients of change of entropy and internal energy with change of extension at constant volume and temperature. From the data, the corresponding coefficients at constant pressure and temperature were determined with accuracies of the order 0·03 gm./cm.²/deg. C. and 10 gm./cm.², respectively.

When the individual 'links' of long-chain molecules in a network have anisotropic optical polarizability, the network becomes birefringent when stressed. According to the kinetic theory, which assumes that no crystallization is present, the stress (for simple elongation) should be proportional to the magnitude of birefringence, and the constant of proportionality, or 'stress–optical coefficient', should not depend on the concentration of network junctions. Dr. D. W. Saunders (British Rayon Research Association) presented data obtained at temperatures above the crystal melting points which agreed with both these theoretical predictions in the case of cross-linked natural rubber and gutta percha. For polythene and polymethylene, however, the stress–optical coefficient decreased with increase of junction concentration; this was satisfactorily accounted for by extending the theory to apply to short-chain networks, and the data indicated that these two polymers had comparatively stiff chains. The problem of giving a strict definition of chain stiffness was considered.

The creation and loss of junctions in a network deformed from its unstressed state were considered in a theoretical paper by Dr. J. Scanlan (British Rubber Producers' Research Association). Tobolsky and co-workers have postulated a form of strain–energy function which would be obtained if the actual network behaved as if it were two independent networks, each of which obeyed the kinetic theory. Dr. Scanlan showed that, in the case in which junctions are created but none is lost, this postulate can be justified, but in the case in which one junction is lost for every one created (in the deformed state), the postulated strain–energy function is correct in form but contains coefficients which must be corrected. Two arguments were presented—one based on the network theory of James and Guth, and the other on a corrected form of a theory given by Scott and Stein.

Elastic recovery, flow and stress relaxation. A striking demonstration of high elastic recovery in a liquid was given by Dr. A. S. Lodge (British Rayon Research Association), who poured a liquid (containing about 5 per cent aluminium laurate in paraffin) out of a bottle; on sharply cutting the liquid stream with scissors, the upper part of the stream snapped back into the bottle. Dr. Lodge has applied the network theory of James and Guth and the theory of relaxing networks of Green and Tobolsky to the problem of elastic recovery in solutions of long-chain molecules; for the instantaneous recovery following steady laminar shear flow, the latter theory predicts an unexpected expansion in directions normal to the previous flow lines. The suggestion that this might contribute to the diameter increase commonly observed when polymer solutions and melts are extruded from tubes of circular cross-section gave rise to considerable discussion, and alternative explanations, also in terms of elastic recovery, were mentioned by Dr. P. Clegg (Imperial Chemical Industries, Plastics Division). Dr. Clegg's data for molten polythene showed that at low flow

rates the diameter increase did not depend on tube length (in agreement with Dr. Lodge's theory) but did depend on tube length at higher flow rates when the transit time through the tube became comparable with the stress relaxation periods of the melt. In this case, the melt was presumably 'remembering' its convergent flow at the entry to the tube. The main part of Dr. Clegg's paper dealt with still higher flow rates, when marked irregularity occurred in the extruded filament. By observation of the motion of embedded particles and of coloured parts of the polymer, Dr. Clegg established that the cause of the irregularity lay in the conditions of flow in the region of entry to the tube; a motion film was shown which clearly demonstrated very marked disturbances of flow in this region. Independent measurements of melt elastic properties suggested that polymers for which the irregular flow sets in at lower shear stresses (or rates) have longer stress relaxation times.

Unoriented polymers crystallize if left long enough at suitable temperatures; crystallization can be accelerated by stretching processes which cause appreciable molecular orientation. To separate these causes of crystallization as far as possible, Dr. E. L. Foster and H. Heap (Imperial Chemical Industries, Fibres Division) have constructed an apparatus with which a filament can be heated rapidly (in about 1 sec.) and its tension–extension characteristics measured. Data for amorphous polyethylene terephthalate ('Terylene') in the range 90°–120° C. showed that at low rates of strain the filament can be extended almost indefinitely with little increase in tension; at high rates of strain, however, the tension increases catastrophically with marked increase in crystallinity, as indicated by X-ray data.

Many measurements have been made of the relaxation of tension in a polymer strip which is rapidly extended and then maintained at constant extension. Prof. G. Gee, Dr. G. Allen and B. E. Read (University of Manchester) have constructed an apparatus in which the electronic recording of tension enables measurements to be made during the first ten seconds when most of the relaxation occurs, as well as at later times. Data were presented for natural rubber at moderate extensions (up to 50 per cent) and at temperatures in the range 45°–60° C., so that crystallization would be very limited. The data taken at the longer time intervals were used to calculate values for the activation energy and activation flow volume.

Elastic recovery in polythene rods has been investigated by J. J. Benbow (Imperial Chemical Industries, Akers Research Laboratory). A rod was held twisted for a given time, released, and the subsequent untwisting measured as a function of time. Only at very small strains (about 0·1 per cent) did the results agree with a theoretical relation obtained by combining Boltzmann's theory of the 'elastic after-effect' with the empirical result that internal friction in polythene subjected to oscillatory strains is independent of frequency. Polythene appeared less able to 'remember' the duration of the imposed twist as the magnitude of this twist was increased. The temperature was controlled at 30° C.; the maximum strain imposed was about 100 per cent.

Miscellaneous properties of polymeric materials. In the mechanical response of polymeric materials to oscillatory strains of very small amplitude, an increase of temperature can, in a sense, be compensated for by a decrease of frequency. Ferry has given a prescription for the appropriate changes of temperature and frequency scales whereby the data for dynamic modulus and dynamic viscosity for a given polymer can be superposed in master curves over a remarkably wide range. A. R. Payne (Research Association of British Rubber Manufacturers) gave a wealth of data showing the successful application of Ferry's method to various cross-linked and uncross-linked rubbers, for dielectrical as well as for mechanical measurements. In these correlations, there is only one disposable constant, a characteristic temperature the value of which is assigned empirically for each polymer. Mr. Payne also discussed data already published for a wide variety of polymers with particular reference to the temperature variation of the frequency at which the maximum value of tan δ occurs, where δ denotes the dielectric loss angle.

In order to obtain a rational measure of tear resistance of a cross-linked rubber, the growth of tears in rubber has been studied under controlled conditions. The concept and determination of a characteristic tearing energy was discussed by Dr. H. W. Greensmith (British Rubber Producers' Research Association). Measured values of this tearing energy showed much greater variation both with temperature and with rate of tearing for a synthetic rubber (*GR–S*) than for a natural rubber. The difference was attributed to the reinforcing effect of crystallization in the natural rubber. Addition of a filler to the synthetic rubber introduced a new maximum in the tearing energy when expressed as a function of temperature and tear rate.

Exposure of a polymer to radiation from an atomic pile or from a high-energy electron accelerator usually either creates cross-links (network junctions), or breaks chains, but rarely does both together. Mechanical properties of polymers are in the main the same, whether the cross-linking is effected by irradiation or by more conventional chemical means. Dr. A. Charlesby, Miss J. Burrows and T. Bain (Tube Investments Research Laboratories) have measured the modulus, stress–strain curve, elongation at break, and tensile strength for irradiated rubbers reinforced with carbon black, with sulphur, and with other additives. No significant difference was observed as between 'electron' radiation and pile radiation; the changes produced depended only on the total energy absorbed. There was some indication that chemical cross-linking gave a higher tensile strength than irradiative cross-linking. E. Fukada (Imperial College of Science and Technology, London) used γ-radiation to cross-link samples of a commercial polyester resin to which different amounts of styrene had been added. The dynamic modulus and mechanical damping at temperatures in the range 10°–160° C. at a single frequency of 0·22 cycle/sec. were obtained from observations of the horizontal and vertical deflexions of one end of a rod of the polymer which was rotated about its axis (held horizontally) by means of a rotating chuck at the other end.

The conference was attended by more than one hundred people, including visitors from Japan, Germany, France, and a substantial number from Holland. Discussions were always lively, and one was left with an impression of a flourishing field of investigation of considerable fundamental as well as technical interest. Publication of the papers and discussions is in the hands of Pergamon Press.

A. S. Lodge

TREE PHYSIOLOGY

THE physiology of forest trees has long been a neglected subject, partly due, no doubt, to the special difficulties of size and slow development which trees present to the experimenter. Nevertheless, there is evidence that interest in this field is rapidly gaining momentum. What is believed to have been the first major symposium on tree physiology was held at Harvard Forest, Petersham, Massachusetts, during April 8–12, under the sponsorship of the Maria Moors Cabot Foundation. The meeting was attended by physiologists and research workers from the United States, various Commonwealth countries and Europe.

Much of the classical work on tree physiology was concerned with water relations, and it is clear from a number of the papers at the meeting that this is still an active field of work. Prof. P. F. Scholander, of the University of Oslo, critically examined the cohesion theory of the ascent of sap. In the past, one of the major difficulties for this theory has been the fact that water uptake continues even when the water columns in the wood are broken by air 'embolism'. Evidence was presented showing that, in the grape-vine, air entering severed vessels apparently does not spread beyond these vessels, and in the region of the cut sap flow is maintained in the interstices between the vessels. The patterns and rates of moisture movement in trees of various species were dealt with by Dr. K. N. H. Greenidge. A detailed study of seasonal changes in the water-contents of the wood and bark of a large number of species by Prof. R. D. Gibbs (McGill University, Montreal) showed that several distinct seasonal patterns may be recognized in hardwoods, and in many cases similarities in these patterns followed the taxonomic relationships of the species. The mechanism of maple sap flow has long puzzled plant physiologists, and a detailed re-assessment of this problem was given by Prof. J. W. Marvin (University of Vermont). Using an automatic recording device, he found that variations in the rate of flow in the spring appear to be related to temperature conditions *preceding* the time of flow. Yet another aspect of the water relations of trees was dealt with by Dr. E. C. Stone (University of California), who reported work on dew-absorption by seedlings of various species of conifer. It was shown that certain species are capable of surviving for long periods after the soil moisture has been reduced to the ultimate wilting point by the absorption of artificial dew applied to the leaves, suggesting that natural dew may be an important source of moisture for these species under desert conditions.

Problems of photosynthesis in trees were dealt with by three speakers. Prof. P. J. Kramer discussed the photosynthesis of trees in relation to various environmental factors, and indicated how a consideration of this problem is of value in determining why forest trees react to environmental factors as they do. Prof. B. Hüber (Forst botanisches Institut, Munich) described experiments to measure photosynthesis and respiration continuously in the field, using an infra-red recorder. In this way it was possible to study daily variations in the carbon dioxide content of air over a vegetation cover. Changes in photosynthetic efficiency of seedlings of *Pinus taeda* with increasing age were shown by Dr. F. H. Bormann (Dartmouth College, Hanover, N.H.) to be related to changes in the morphology of the primary and secondary leaves.

Several speakers dealt with the translocation of metabolites in trees, and a lively discussion on the possible validity of the 'mass-flow' hypothesis of Münch constituted an important part of the symposium. Prof. Hüber described observations on the daily variation in composition of phloem sap. These observations suggest that the entrance of food material into the sieve tubes is an active process, whereas its translocation appears to be essentially passive, since such different substances as fluorescein, sugars and radioactive isotopes move in the same direction and with similar velocities. Dr. M. H. Zimmermann (Harvard Forest) has examined the sieve-tube exudates of sixteen tree species. Observations on the diurnal and seasonal fluctuations in the gradient of sugars in the phloem are consistent with the 'mass-flow' theory. A novel way of obtaining samples of phloem sap, by cutting off the stylets of aphids, was described by Dr. T. E. Mittler (Unit of Insect Physiology, Cambridge). The method has also been used with isolated stem segments to investigate the possible mechanism of phloem transport.

The importance of the xylem sap in the transport of organic nitrogenous materials was dealt with by Dr. E. G. Bollard (Department of Scientific and Industrial Research, New Zealand). A survey of more than a hundred species showed that they can be divided into three groups, according to the type of organic nitrogenous compounds predominant in the xylem sap. In the majority glutamine or asparagine was the principal compound; in some species citrulline was predominant, while in a third group allantoin or allantoic acid was present in the greatest quantities. By injecting rubidium-86 and calcium-45 into the trunks of yellow birch and white pine, Dr. D. A. Fraser (Petawawa Forest Research Station, Chalk River, Ontario) was able to follow their upward movement in the xylem in the growing season, and the downward movement in the phloem in the autumn.

Two papers dealt with the distribution of chemical constituents in relation to taxonomic groups. The distribution of turpentines in a hundred species of the genus *Pinus* has been studied by Dr. N. T. Mirov (California Forest Experiment Station), who was able to relate similarities in the chemical constituents to taxonomic affinities. Prof. R. D. Gibbs described the results of the Mäule test (which indicates the presence of the syringyl group in the wood) with more than a thousand vascular plants. The taxonomic significance of the results was discussed.

The problem of frost-hardiness in *Robinia pseudo-acacia* has been studied by Dr. D. Simonovitch (Science Service, Ottawa). He found that seasonal changes in the frost-resistance of the living bark are closely associated with changes in the protein constituents, using electrophoretic methods.

Dr. L. Leyton (Department of Forestry, Oxford) described observations on the relationship between tree growth and the mineral composition of the foliage of conifers, as a basis for the foliar diagnosis of mineral deficiencies. He gave examples in which this approach has been successfully employed in the diagnosis of deficiencies.

Several sessions were devoted to various aspects of growth physiology in trees. Four papers dealt with problems of root-growth. Dr. S. D. Richardson (University of Aberdeen) described experiments dealing with the interaction between shoot- and root-growth in sycamore (*Acer pseudoplatanus*), especially

during the period of shoot dormancy. Disbudding experiments suggest that even in apparently dormant seedlings, root development is dependent upon physiological activity of the buds, and the possibility that auxin produced by the bud stimulates lateral-root initiation was suggested. The possible role of auxin secreted by the fungal symbiont in the formation of mycorrhizal roots of pine was discussed by Dr. V. Slankis (Laboratory of Forest Pathology, Maple, Ontario). It has proved possible to reproduce mycorrhiza-like root morphology by applying synthetic auxins in the absence of the fungus. Dr. S. Shapiro (Brookhaven National Laboratory) described the effect of light on the emergence of roots on stem cuttings of Lombardy poplar. A few minutes of exposure to low-intensity illumination is sufficient to inhibit the emergence of the roots. The most active region of the spectrum lies in the red (6800 A.), the effect of which is partially reversible by far-red radiation. Polarity phenomena in the regeneration of buds by Lombardy poplar were also described.

The effect of aeration in root growth of trees was dealt with by Dr. Leyton. In the absence of oxygen, root-growth ceased in jack pine (*Pinus banksiana*) and black spruce (*Picea mariana*), whereas willow (*Salix atrocinerca*) is able to continue root-growth without any apparent deleterious effect on the shoot.

Various other aspects of growth were covered by several speakers. The rate of cytoplasmic streaming in the cambial initials of *Pinus strobus* was studied by Prof. K. V. Thimann (Harvard University). The effect of indolyl acetic acid, enzyme inhibitors and oxygen tension was described. Cytoplasmic streaming shows marked seasonal variations. Dr. P. White (Jackson Memorial Laboratory, Bar Harbor) described tumours occurring on white spruce (*Picea glauca*), which arise as sectorial chimæras originating from single cells. In tissue culture, the tumour tissue shows characteristic metabolic differences from normal tissue. Variations in the amount of extractable auxin, in relation to developmental changes of longleaf pine (*Pinus palustris*), were described by Dr. C. L. Brown (Texas Forest Service), and seed dormancy in various species of pine was discussed by Prof. E. C. Stone.

A further session was devoted to photoperiodism in trees. Dr. R. T. Downes (U.S. Department of Agriculture, Beltsville) indicated the broad range of photoperiodic phenomena in tree seedlings. Dr. P. F. Wareing (University of Manchester) gave a comparative study of photoperiodism in seeds, buds and seedlings of a single species, *Betula pubescens*. The possible role of growth inhibitors in both seeds and buds was considered. Prof. S. S. Pauley (University of Minnesota) emphasized the importance of photoperiodism in forest tree breeding.

The importance of 'thermoperiodism' in loblolly pine (*P. taeda*) was demonstrated by Prof. Kramer. Best growth was made with the greatest difference in day and night temperatures. Species of oak show similar effects. It was suggested that 'thermoperiodism' may be important in limiting the range of some species.

The increasing importance of forest genetics has emphasized the need for a greater knowledge of the physiology of reproduction in trees, and there are signs that this subject is beginning to arouse widespread interest. Dr. K. Sax (Arnold Arboretum) described experiments designed to elucidate the physiological basis of several methods long used by horticulturalists to induce earlier flowering in trees, namely, the use of dwarfing rootstocks, bark inversion and knotting of the stem. A study of flower initiation in spruce in relation to various external conditions was described by Dr. D. A. Fraser.

Reproduction in pine was the subject of two papers. Dr. R. G. Stanley (California Forest Experiment Station) is carrying out a biochemical study of male, female and vegetative structures of pine, and attempting to identify differences in metabolites and enzyme patterns. Dr. Wareing outlined observations on the reproductive development of Scots pine and attempted to relate this development to the 'ageing' of the tree as a whole and of the individual branches.

There can be no doubt that the meeting was an outstanding success and will constitute a landmark in the development of this field of study. Tree physiologists are indebted to the Cabot Foundation, and especially to Prof. Thimann and Dr. Zimmerman as organizers of the meeting, for bringing them together to their mutual benefit. The proceedings of the symposium are to be published in full.

P. F. Wareing

NEW NATURE RESERVES IN BRITAIN

THE Nature Conservancy has announced the establishment of the following new nature reserves in England and Wales: Rodney Stoke Woods, Somersetshire; Coed Tremadoc, Caernarvonshire; Craig Cerrig Gleisiad, Breconshire; and the existing reserve at Coed Rheidol in Cardiganshire has been extended.

Rodney Stoke Woods—on the southern escarpment of the Mendip Hills—are the best example of a Mendip ash wood existing to-day. These Mendip woods are a scientifically interesting variant of the ash woods found throughout Britain on carboniferous limestone, which here underlies most of the reserve and in parts is exposed. The Reserve consists of an ash wood together with some rough grazing and covers an area of 65 acres: the highest part is 750 ft. above sea-level and the lowest about 200 ft. In these woods ash is the dominant tree and associated with it are the wych elm and field maple: the shrub and herb layers are very well developed. The whitebeam is common and the autumn crocus is locally abundant, while the blue gromwell is found in suitable habitats. Other characteristic plants of these woods are *Campanula trachelium*, *Daphne laureola* and the small-leaved lime. Rock rose is common in the old pasture and ferns such as hart's tongue, and *Asplenium trichomanes* occur in the rock crevices. The fauna is typical of the dryer Mendip woods, including badger, buzzard and many species of mollusc.

Access to this reserve, which will be used for research on ash wood and its ecology, will be by permit only. Applications for such permits and for authority to collect specimens of animals and plants should be sent to the Regional Officer for the South West, Nature Conservancy, Furzebrook Research Station, Wareham, Dorset.

The woods at Coed Tremadoc clothe precipitous cliff faces and the screes below them, and are a good

example of survival of oak-woodland, which at one time was frequently found on cliff and rock faces in Wales up to quite high altitudes. Owing to extreme steepness, many of the ledges and gulleys of the cliffs have escaped the intensive sheep grazing and human interference which has had such a great effect on almost every kind of vegetation in Britain. The reserve lies 1½ miles north-east of Portmadoc and covers 41 acres. It is the third reserve within the Snowdonia National Park, and has been established under a lease from Capt. S. T. A. Livingstone-Learmonth. The cliffs are composed of dolerite, which is a basic intrusive igneous rock, though basic ashes and shales also occur. The vegetation is very complex, due to the variability of the habitat and its instability. Sessile oak is characteristic with some admixture of pedunculate oak and ash. Sycamore has obtained a footing on the lower scree slopes. On the larger ledges and margins of scree such plants as marjoram and privet—both usually plants of chalk and limestone—are found; while on smaller ledges and rock faces ivy, bell heather, ling, honeysuckle, wood sage, sweet vernal grass, and composites, such as cat's ear, are prevalent, together with stunted, windswept oak. The shales have a flora which is more characteristic of acid soils and includes wavy hairgrass. Among the mosses, the rare *Hedwigia integrifolia* occurs. The crags are also the haunt of many small mammals and of birds, including the raven and peregrine falcon.

Craig Cerrig Gleisiad and Craig Cwm Du are two Old Red Sandstone crags about a mile apart and surrounded by moorland. They lie at the western end of the high glaciated ridge of the Brecon Beacons, within the Brecon Beacons National Park, between the 1,600 and 2,000 ft. contours, and about six miles south-west of Brecon. The part of the reserve now being declared is the western or Cwm Du portion, comprising 576 acres. It runs westward from the north end of Craig Cerrig Gleisiad and includes the whole of Craig Cwm Du cliffs (highest point about 1,750 ft.), the Nant Cwm Du valley and stream at their foot on the north side, and the moorland extending north and east up to and including the rock outcrops of Fan Frynych. The reserve has been established under a Nature Reserve agreement with the owner, Mr. S. E. Lewis. Negotiations are in progress to include the eastern cliffs of Craig Cerrig Gleisiad. The botanical interest is centred on rare arctic–alpine plants, notably purple saxifrage (*Saxifrage oppositifolia*), globe flower (*Trollius europaeus*), green spleenwort (*Asplenium viride*), and lesser meadow rue (*Thalictrum minus*). The two cliffs form the southernmost limit for this element in the British flora. The adjacent moorland is of a more general ecological interest, with varied upland vegetation types including much bilberry and matgrass.

In September 1956 the Nature Conservancy established the Coed Rheidol Nature Reserve covering an area of 18 acres. Two further small areas have now been added to this reserve; they lie on the western bank of the River Rheidol and link up with the small section of Dolgamfa Wood, which was included in the previous declaration, so that three-quarters of a mile of the western bank and half-a-mile of the eastern bank are now within the reserve, covering an area of 54 acres. The additional areas occupy steep rocky slopes ending in the vertical cliff of the river gorge. The rocks here consist largely of steeply inclined slabs of slate and shale, which are unstable and consequently the nature of the ground here is extremely hazardous. The woodlands have an interesting flora particularly rich in moisture-loving and shade-loving plants including many species of mosses.

Applications for permits, which will be necessary for those who wish to collect specimens of animals or plants in the Coed Tremadoc, Craig Cerrig Gleisiad or Coed Rheidol reserves, should be made to the Conservation Officer, Nature Conservancy, Y Fron, The Crescent, Upper Bangor, Bangor, Caernarvonshire.

CARNEGIE INSTITUTION OF WASHINGTON

REPORT FOR 1955–56

THE Year Book 1955–56 of the Carnegie Institution of Washington includes, besides the report of the President, reports of Departments and Special Studies and of the Executive Committee and Auditors. That of the Mount Wilson and Palomar Observatories refers to the completion during the year of the National Geographic Society–Palomar Observatory Sky Survey. A survey has been made of the present state of knowledge of the abundances of the elements in stellar atmospheres, and the programme of observations of stellar magnetic fields and on the internal motions in the Orion nebula continued, while the investigation of cepheid variables and other distance variables in the Andromeda galaxy was virtually completed. An outstanding event was the explanation of the light-emission in the Crab nebula as due to electrons circulating in a magnetic field, and a theoretical study has been made of the sources of radio emission in *N.G.C.* 5128 and *N.G.C.* 1316. An improved photoelectric guide has been developed for use at the coudé focus of the 200-in. telescope and two completely new photometers designed by Baum are being made for the 60-in. and 100-in. telescopes at Mount Wilson. The Joint Committee on Large Tubes for Telescopes is attempting to extend both the effective distance in space accessible to such instruments and spectrum measurements down to much fainter objects.

The Department of Terrestrial Magnetism found definite periodicities in the occurrence of radio-noise bursts from Jupiter, which were correlated with the rotational period of the non-equatorial regions of the planet. Exploration of the continental crust was extended into Alaska and the Yukon territory, and in rock-magnetism studies—in a co-operative project with the Bernard Price Institute for Geophysical Research at Johannesburg—progress was made in ascertaining the conditions under which a primary magnetization can survive under the influence of time and natural processes. A method has been developed for using the discordant ages calculated for uranium minerals to deduce the probable history of a group of such minerals subjected to the same sequence of events. In nuclear physics the study of low-lying nuclear energy-levels by the method of Coulomb excitation continued, and further evidence has accumulated in support of the Bohr–Mottelson unified model of the nucleus. In biophysics knowledge of the characteristics of the relatively loosely held 'pools' into which small molecules are concentrated before being linked into macromolecules has

been greatly increased, some of the immediate precursors of nucleic acid have been determined, and an upper limit of three seconds established as the time required for protein synthesis, most of the work being carried out with *Escherichia coli* but some with *Torulopsis utilis*. Radioactive tracer studies were carried out with *Hydra littoralis* and carbon-14 glucose. Amino-acid tracers have been followed from a subcutaneous injection through the blood into cellular pools of free amino-acids and into the protein of new-born mice. During the year application of the membrane-filter technique to the problem of nucleic acid synthesis in *E. coli* demonstrated the formation and utilization of metabolic pools of precursors, and indicated the part played by phosphorylated intermediates. A comparatively full account of this work is given in the Departmental report, while that of the Geophysical Laboratory, which had a particularly stimulating and productive year, includes detailed accounts of the work on phase equilibria at high pressure, in which an apparatus has been constructed capable of achieving pressures of 60,000 atmospheres at about 700° C., with which studies have been made of minerals, such as might exist deep in the Earth, of the stability of hydrous iron silicates on primitive magmas, and of the age of rocks and minerals in a co-operative programme with the Department of Terrestrial Magnetism which has shown that concordant ages for potassium-40/argon-40 and rubidium-87/strontium-87 are obtained when measured on ancient minerals. Other work, which has shown that amino-acids such as glycine, sarcosine, alanine and β-alanine can be formed from a variety of primitive atmospheres, work on sulphide systems, which has shown that pyrite (FeS_2) is stable below 815° C. at 5,000 bars, and work on feldspars and feldspathoids, on statistical petrology, and on the routine absolute measurement of beta radioactivity at low level from thick samples, in which a general relation was discovered between the beta-absorption coefficient and the maximum energy of the radioactivity, is also described in detail.

The Department of Plant Biology has obtained evidence suggesting an active participation of carotene in the photochemical action of chloroplasts and, by a simple method developed for recording the absorption spectra of small amounts of pigments in living leaves, an unsuspected intermediate form of chlorophyll was discovered. Further progress was made in the work on the purification and characterization of the protochlorophyll–protein complex from leaves grown in the dark, and it has been found that the frozen and dried, partly purified, proteinaceous particles can transform the protochlorophyll to chlorophyll when illuminated in the dry state just as readily as when dissolved in water. The changes of absorption in *Chlorella* induced by light have been correlated with the ability of this alga to emit light, and three different types of active spectra have been found in studies of the effectiveness of light of different wavelengths in orientating the swimming of dinoflagellates. Data for a description of the behaviour of new types of hybrid grasses are expected to be complete in the next three years, and a comparative study of fifteen apomictic lines derived from a single first-generation hybrid between *Poa ampla* from Kahlotus, Washington, and *P. pratensis* from Athabasca, Canada, indicate that a very wide range of selection is possible among the progeny of a single new, sexually reproducing hybrid. Stable apomictic derivatives from the combination *P. ampla* from the Palouse Prairie region and *P. arida* from Nebraska have been produced for the first time.

In the Department of Genetics new experimental evidence was obtained that large, functionally intact pieces of viral nucleic acid may pass from parent to offspring phage, while genetic analyses, by the transduction method, of short regions of the chromosome complex of the bacterium *Salmonella typhimurium* have shown that mutations occurring at different sites of a single locus, although they affect one function primarily, may produce mutants differing considerably from one another in various properties. Several different controlling elements in the maize chromosome complement have been identified, and electron micrographs of salivary glands of *Drosophila* and of dividing cells of *Tradescantia* have been interpreted as indicating that the patterns of organization of their chromosomes represent a hierarchy of pairs of helically disposed chromonemata. Studies of the effect of ribonuclease, ethylenediaminetetraacetate and calcium chloride on *Drosophila* and onion roots indicate that any agent which disrupts the normal metabolism of the cell can lead to instability reflected in modification of chromosome form and behaviour. The stage of development of the salivary-gland cell in *Drosophila* at which 'blebbing' of the nuclear membrane into the cytoplasm occurs has been correlated with the assumption of a new function by the cell. A mathematical analysis of the dynamics of bacterial populations was completed.

In the Department of Embryology exploration of the chemodifferentiation of the heart-forming areas of the early chick embryo demonstrated that antimycin *A* acts as a specific inhibitor of heart formation, while studies on the mechanism of the spacing of blastocysts along the rabbit uterus showed that the spacing was due to the delicate interaction of two mechanisms dependent on progesterone. Studies of the nature of the fluid of the rabbit oviduct were concluded, progress is reported in the analysis of the vascular changes in the menstrual cycle in the rhesus monkey, and further investigations of the vascular patterns of the placenta indicate that maternal blood enters the intervillous space from small blood vessels, the spiral arterioles, under a head of maternal pressure. The first phase of a study of the effects of reserpine on the reproductive cycle of the rhesus monkey was completed.

CHEMICAL RESEARCH LABORATORY

REPORT FOR 1956

THE wide variety of research now in hand at the Chemical Research Laboratory is described in a report* entitled "Chemistry Research 1956", published by H.M. Stationery Office for the Department of Scientific and Industrial Research. The investigation of corrosion problems has been continued. It includes research into the possibility of improving the efficiency of corrosion inhibitors for use in anti-freeze mixtures for engine-cooling systems, the study of the rapid pitting of boiler tubes in marine boilers, which it was found could be prevented by the addition

* Chemistry Research 1956: The Report of the Chemistry Research Board with the Report of the Director of the Chemical Research Laboratory. Pp. vi+86. (London: H.M. Stationery Office, 1957.) 4s. net.

of small amounts of copper to the steel used in the manufacture of the tubes, the discovery that the corrosion of buried pipes and underground fittings was due to the bacterial reduction to sulphide of large amounts of sulphates in the soil, and the corrosion of fuel pumps in aircraft by sulphur compounds, produced by bacterial reduction of sulphates in water, finding their way into petroleum above the water storage tanks. There were also purely scientific investigations of corrosion.

Work on the separation of a number of rare earth metals by the use of columns of ion-exchange resins yielded important results improving the understanding of the process and in particular the control of the various factors involved in a separation. Improved techniques have made possible better separations of light-earth fractions than have previously been achieved. A large-scale apparatus capable of handling kilogram quantities of rare earths is now being used for this work. A simple but very effective method for the purification of mercury is described; investigations of the purification of elements of interest as semiconductors are in progress, and reliable methods of measuring very small amounts of impurities in such materials are under investigation.

Work on the extraction of uranium and thorium from minerals and ores is being done on behalf of the United Kingdom Atomic Energy Authority, and new recovery methods are being studied. A great increase in the use of radioactive tracer techniques has taken place during the year.

Much valuable work has been done on the properties of pure organic compounds and the mechanism of organic reactions. Determinations of heats of combustion are being carried out in collaboration with the National Physical Laboratory. Two principal lines of investigation into high polymers are the study of the structure and permeability of polymer films, and work on the fractionation of polymers and the determination of their molecular weights. Basic research into the ion-exchange and allied properties of cross-linked polymers is being continued. The preparation of ion-selective polymer films is of particular industrial importance in the treatment of brackish water and also of effluents.

It will be seen that the Chemical Laboratory is actively engaged on a large number of researches of both purely scientific and industrial interest. The report is by no means a bare summary of this work but is an interesting and useful source of much information which research workers will be pleased to have in such a compact form. The cover of the book shows a portion of the periodic table, and, of the atomic weights in it, fifteen differ from the values in the 1955 international table.

AUTONOMOUS ACTION OF LETHAL MUTATIONS INDUCED IN THE GERM CELLS OF *DROSOPHILA MELANOGASTER* BY 2-CHLOROETHYL METHANESULPHONATE

By C. E. PURDOM*

Chester Beatty Research Institute, Institute of Cancer Research, Royal Cancer Hospital, Fulham Road, London, S.W.3

IN young *Drosophila* males the sperm to be utilized for successive broods of offspring comes from successively earlier stages of spermatogenesis in the testis, from mature sperm to early spermatogonia. Following treatment with a mutagen, the pattern of effect measured in successive broods will be a reflexion of the sensitivity of the various germ cell stages to the action of the mutagen.

The mutagenic properties of 2-chloroethyl methanesulphonate (*C.B.* 1506) have been studied by Fahmy and Fahmy[1], who found that the ratio of sex-linked recessive visibles to lethals rises in the later broods, from 0·35 in broods utilizing sperm from post-meiotic cells to 0·6–1·0 in broods utilizing sperm from pre-meiotic cells at the time of treatment. Three possible explanations of the phenomenon may be listed.

(1) The mutagen may have some specific action on the visible loci concerned. This presupposes some common chemical properties of the visible loci as a whole as compared to the lethals as a whole and also leaves unexplained the difference between pre- and post-meiotic cells.

(2) The mutagen may induce more 'point mutations' in the pre-meiotic cells. This would produce an increase in the visible to lethal ratio, since in larger areas of chromosomal damage, the locus with the earliest action[2] would be the definitive one, masking the presence of others, in this case, visibles.

(3) Essentially the same proportions of the different mutations may be produced in all cells; but some of the lethals induced in the pre-meiotic cells may act autonomously, killing the cell before it produces sperm, thereby increasing the observed proportion of visibles.

This present investigation was undertaken to examine the last possibility, that the increase in the ratio of visibles to lethals was produced by adverse selection in the germ line against lethals functioning autonomously.

Approximately 0·2 µl. of a 0·2 per cent solution of *C.B.* 1506 in 0·4 per cent saline was injected into the abdomens of *Drosophila* males (Oregon-*K* stock), 48 ± 4 hr. after emergence. The treated males were tested by the *Cy*/*L* technique[3] for the detection of autosomal (2nd chromosome) and sex-linked mutations. Lethals were scored as cultures containing no non-Muller-5 males at all in the F_2 and confirmatory F_3 for the sex-linked data, and no Cy^+/L^+ flies in the F_3 and F_4 for the 2nd chromosome data. Visible

* Gordon Jacob Fellow, Royal Marsden Hospital.

Table 1. A Comparison of the Induction of Sex-linked Recessive Mutations (*A*) and 2nd Chromosome Recessive Lethals (*B*), by *C.B.* 1506

	Days	4	2	3	3	3	3	3	3
A	Brood	I	II	III	IV	V	VI	VII	VIII	IX
	Total chromosomes tested	1,501	406	249	117	161	135	9	166*	58
	Total lethals	16	2	16	4	16	16	—	6	4
X_2	Lethals (per cent)	1·1	0·5	6·5	3·4	10·0	12·6	—	3·6	6·9
	Weighted mean	$M_2 = 3·6$; $\sigma_2 = 0·41$					9·6			
	Total visibles	1	1	7	2	7	10	—	9	—
	Visibles/lethals	0·06	0·5	0·4	0·5	0·4	0·63	—	1·5	—
	Total visibles/lethals	0·29					0·73			
B	Total chromosomes tested	707	282	181	69	110	81	15	80*	34
	Total lethals	17	10	21	6	29	39	12	43	25
X_1	Lethals (per cent)	2·4	3·5	11·6	8·7	26·4	48·0	80·0	53·7	73·6
	Weighted mean	$M_1 = 6·7$; $\sigma_1 = 0·76$					50·6			
	Ratio II/*X*	2·2	7·0	1·8	2·6	2·6	3·8	—	14·9	10·7
		$1·9 \pm s_Z\dagger = 0·11$					5·3			

* One group of 31 F_1 cultures (*A*) and 25 F_2 cultures (*B*) from a single male which was infertile in all other broods has been eliminated.
† $Z = \frac{X_1}{X_2}$; $s_Z^2 = \frac{M_1^2}{M_2^2}(v_1^2 - 2 r v_1 v_2 + v_2^2)$; $v_1 = \frac{\sigma_1}{M_1}$; $r = 0·87$.

mutations were scored in the sex-linked experiment only, and scored as mutations producing any non-Muller-5 males which showed any deviation from the Oregon-*K* phenotype. 'Semi-lethals' which produced a marked reduction in the numbers of wild-type males in the F_2, but with no phenotypic deviation, were not classed as visibles nor included in the lethal data.

The results are shown in Table 1 and represented graphically in Fig. 1. Broods I–IV and VI–IX are taken together, since the comparisons to be made are between post-meiotic mutations I–IV, and pre-meiotic mutations VI–IX. Brood V is not included in either since overlapping may occur here. The yield of 2nd chromosome lethals is approximately double that of sex-linked lethals for the first four broods. A two by four contingency table of the sex-linked and 2nd chromosome lethals in the first four broods gives a value of $\chi^2 = 2·9$; $\nu = 2$; $P = 0·25$; thus there is no indication of heterogeneity throughout these broods. For broods I–IX (except VII) $\chi^2 = 16·5$; $\nu = 6$; $P = 0·01$. This indicates a considerable amount of heterogeneity in the results which must be due to the increase in the ratio of autosomal to sex-linked lethals in the later broods, the value 5·3 for broods VI, VIII and IX being well outside 3*s* for broods I–IV, the ratio being $1·9 \pm 0·33$ (Table 1).

The data on visible mutations are not sufficiently large for statistical analysis, but agree in general with the data from the larger experiments by Fahmy and Fahmy[1], in showing a disproportionate rise in frequency as compared to lethals in the later broods. The exceptionally low incidence of visibles in brood I in the present experiment is probably not significant.

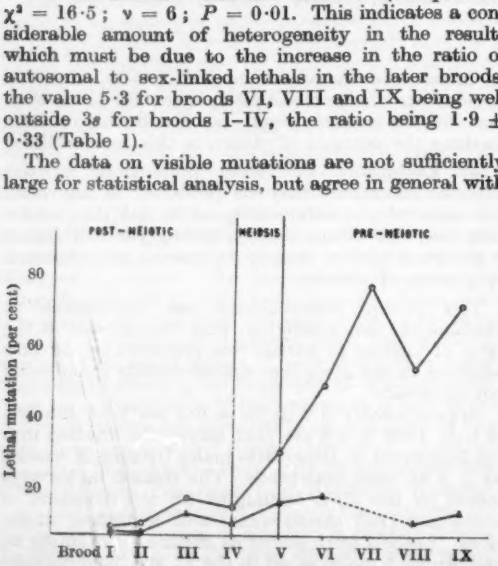


Fig. 1. The brood pattern of *X*-chromosome lethals (△), and second chromosome lethals (○), induced by 2-chloroethyl methane-sulphonate

The autonomous nature of many lethal mutations in somatic tissue of *Drosophila* has been demonstrated by Ephrussi[4], Démerec[5] and Stern[6], who studied the fate of cells homozygous or hemizygous for a lethal mutation, arising by somatic crossing-over or non-disjunction in viable heterozygotes, and found that even single cells surrounded by normal tissue die. Similarly, Gloor[7] demonstrated that some lethal factors function autonomously in male germ cells transplanted into genetically normal hosts, the germ cells not developing beyond the stage they normally reach in the donor. Thus an *a priori* consideration may be given to the interpretation of the results of Fahmy and Fahmy[1] and of the present investigation in terms of germinal selection by autonomous action.

Of the three explanations given in the introduction, the first clearly lacks experimental or theoretical support. The second is also untenable, since if more 'point mutations' were produced in the later broods, the same proportion of autosomal and sex-linked lethals should be produced throughout, and this is clearly not so. The third explanation fits the observations. Developing spermatids and spermatozoa seem to be protected against the harmful effects of quite drastic genetical damage, since extensive chromosomal aberrations which later produce dominant lethality persist in sperm which is still capable of fertilization. Therefore, the proportions of these lethal mutations and sex-linked visibles detected in the late germ cells are a good estimate of the actual proportion produced in the cells themselves. The results show a striking increase in the yield of autosomal recessive-lethals and sex-linked recessive visibles against sex-linked recessive lethals in late broods. The former mutations are both ineffectual when induced in pre-meiotic cells; the autosomal lethals exist in the form of viable heterozygotes, the visibles are by definition non-lethal; whereas sex-linked lethals in the hemizygous state may be eliminated by autonomous action. Since there is no evidence that the above classes of mutations are produced in different proportions in different chromosomes, throughout the stages of the germ line, it must be concluded that the divergence in the relative yields of autosomal lethals and sex-linked visibles from sex-linked lethals

is most probably due to adverse selection against the latter by autonomy.

I wish to thank Dr. O. G. Fahmy for his interest in this work. This investigation has been supported by grants to the Chester Beatty Institute (Institute of Cancer Research, Royal Marsden Hospital) from the British Empire Cancer Campaign, the Jane Coffin Childs Memorial Fund for Medical Research, the Anna Fuller Fund, and the National Cancer Institute of the National Institutes of Health, United States Public Health Service.

[1] Fahmy, O. G., and Fahmy, M. J., *Nature*, **177**, 996 (1956).
[2] Hadorn, E., "Adv. in Genetics", **4**, 53 (1951).
[3] Auerbach, C., *Z. Vererbungslehre*, **86**, 113 (1954).
[4] Ephrussi, B., *Proc. U.S. Nat. Acad. Sci.*, **20**, 420 (1934).
[5] Demerec, M., *Amer. Nat.*, **68**, 165 (1934).
[6] Stern, C., *Proc. U.S. Nat. Acad. Sci.*, **21**, 374 (1935).
[7] Gloor, H., *Rev. Suisse Zool.*, **50**, 339 (1943).

ROLE OF CATIONS IN PHAGE ADSORPTION TO SENSITIVE BACTERIA

By J. BEUMER, J. DIRKX and M. P. BEUMER-JOCHMANS

Institut Pasteur de Bruxelles, Belgium

IT has been shown previously[1] that the adsorption of phage *H-SHPB*(Ca), which is a temperate phage isolated from the lysogenic coliform strain 'Lisbonne', on the *Shigella dysenteriae* strain *SHPB* in broth requires calcium ions, whereas the adsorption of the same phage on another *Sh. dysenteriae* strain (Flexner 6 *S*) does not.

This led us to investigate further the role of cations in adsorption of phage *H-SHPB*(Ca) on sensitive bacteria. The experimental procedure was as follows. To living bacteria from 5-hr. old cultures, suspended in maleate–buffer solutions of various mono- and divalent cations at *p*H 7·3, phage was added at a concentration of about 1 phage to 100 bacteria. After 5 min. in the water-bath at 37° C., 1 ml. of the bacteria + phage mixture was cooled in ice and then centrifugated at 3,000 rev./min. for 5 min.; the bacterial sediment was resuspended in 1 ml. broth and the adsorbed phage was titrated by plating the resuspended bacterial sediment on a sensitive strain (*SHPB*). The percentage of adsorbed phage is calculated directly by comparing the titre of the phage in the bacterial sediment to that initially introduced in the bacterial suspension.

The experimental results (to be published in detail elsewhere[2]) show that in very dilute maleate–buffer solutions no adsorption of the phage takes place and that very precise cationic conditions must obtain for this adsorption to occur. As can be seen from Table 1, in sodium maleate adsorption of the phage on the *R* forms of sensitive bacterial strains (*SHPB*, *Y6 R* and *F6 R*) only takes place at concentrations between 0·01 and 0·04 or 0·06 *M* sodium ions, adsorption being inhibited at higher concentrations. The adsorption of phage on the *S* form (*F6 S*), however, does not occur below 0·03 *M* sodium and is not inhibited by sodium ion concentrations as high as 4 *M*. Other monovalent cations, such as potassium, ammonium or $(CH_3)_2NH_2^+$, are effective at concentrations similar to those of sodium. Divalent cations (calcium, strontium, barium and magnesium) promote adsorption at a concentration of 0·001 *M* or higher; that is, they are ten times more efficient than monovalent cations. Except for magnesium ions, which inhibit adsorption at concentrations higher than 0·04 *M*, no inhibition by divalent cations could be demonstrated at concentrations up to 0·09 *M*, and higher concentrations were found to be toxic for the phage.

Table 1. MOLECULAR CONCENTRATIONS ALLOWING ADSORPTION OF PHAGE *H-SHPB*(Ca) ON:

	SHPB	*Y6 R*	*F6 R*	*F6 S*
Sodium maleate	0·014–0·04	0·016–0·06	0·01–0·06	⩾0·03
Calcium maleate	⩾0·001	⩾0·001	⩾0·001	⩾0·004

Thus the necessity of calcium for the adsorption of phage *H-SHPB*(Ca) on some strains in broth is not a specific requirement for that ion, but the expression of a more general need, that of cations in adequate concentrations, as Puck and his co-workers[3] have shown for the *T*-system of phages. The cationic environment required for phage adsorption varies, not only with the phage as Puck has shown, but also for the same phage with the sensitive strain under test. The *S* strain (*F6 S*) exhibits a behaviour different from that of *R* strains, in being far less sensitive to the inhibition by high concentrations of sodium ions. It has been shown elsewhere[4] that the *R* strains, while not adsorbing the phage in broth (containing 0·2 *M* monovalent cations), are able to adsorb it in broth diluted 1 : 5 with distilled water, because the dilution lowers the concentration of monovalent cations to a level (0·04 *M*) compatible with phage adsorption on the *R* strains. The *S* strain, in contrast, adsorbs the phage in undiluted broth.

Following Puck and Sagik[5], cations are required for phage adsorption, to reduce the negative charge of the phage, so lessening the repulsion energy prevailing between phage and bacteria, which are both negatively charged. Cations seem thus to act only by their electric charge. As we have observed, the adsorption of the same phage on different bacterial strains may require different cationic conditions. In order to find a tentative explanation of the role of cations in phage adsorption, we have investigated the electrophoretic mobilities of both phage and bacteria, with the view of determining their electrical potential.

We find, for bacteria, the classical electrophoretic properties, that is, each ion exerts a weak but specific effect on the mobilities, divalent cations reduce the mobilities by a factor of about 2 and the *R* and *S* strains showed a marked difference in mobilities[6].

From the mobility values, the ζ-potentials were calculated and their values are summarized in Table 2.

The mobilities of the phage at various ionic conditions were determined by the Hittorf method; but, for the subsequent calculations to be performed, hypotheses must be introduced concerning the form of the particle. As shown by electron microscopy, the phage possesses a classical structure with a head

Table 2. Various Electrochemical Characteristics of Phage and Bacteria

Ion	Conc.	ζ-Potential					Charge density of phage (10^{-5})	Ionic density in the ζ-plane of bacteria (10^{-4})			
		SHP B	*F6 R*	*Y6 R*	*F6 S*	*H—*		*SHP B*	*F6 R*	*Y6 R*	*F6 S*
Sodium	8×10^{-2}	85·6	86·6	89·5	56·3	19·6	1·08	5·02	5·17	5·84	2·89
	2×10^{-2}	101·2	96·8	103·0	47·7	24·2	0·667	3·42	3·14	3·53	1·16
	8×10^{-3}	114·3	109·2	111·3	54·8	18·2	0·336	2·58	2·50	2·64	0·765
Calcium	4×10^{-2}	41·2	38·5	37·7	20·9	1·86	0·12	3·36	3·02	2·94	1·42
	2×10^{-2}	49·0	48·0	63·0	27·4	18·0	0·282	1·02	0·978	1·73	0·431
	4×10^{-4}	44·6	46·3	61·8	25·5	14·2	0·108	0·385	0·409	0·740	0·176

All potential values are expressed in millivolts. The charge densities are expressed in number of elementary electronic charges per square micron. Concentrations are in molarities

about 75 mμ in diameter, surmounting a tail 240 mμ in length and 25 mμ in diameter. The lack of knowledge about the frictional coefficient of such a form making the calculation practically impossible, we thus assumed that the phage acts as an 'equivalent cylinder', the length of which is that of the phage and with an 'equivalent radius' of 16·8 mμ. Moreover, we suppose that this particle possesses a permanent dipole which causes the phage to be orientated parallel to the electric field.

On these assumptions we were able to calculate the ζ-potential of the phage and to determine also its charge by using the Gorin equation:

$$Q = \frac{\zeta(L + 2r)\, K_1(\varkappa.r)\, \varkappa.r}{2\, K_2(\varkappa.r)}$$

in which Q is the charge, ζ the ζ-potential, L the length of the equivalent cylinder, r its radius, $\varkappa$ the Debye–Hückel parameter and K_1 and K_2 Bessel functions varying with the product $\varkappa.r$.

We have also calculated the electro-ionic densities of the bacteria in their ζ-plane. All calculated values are listed in Table 2.

If, according to Puck and Sagik[5], the fixation of a phage on a sensitive bacterium results from the neutralization of the negative charges carried by the phage by the positive cations surrounding the bacterium, it may be concluded, from the values in Table 2, that fixation will occur at all concentrations listed here, owing to the fact that the positive charge densities around the bacteria are, in all cases, greater than the negative charge of the phage.

In fact, our experiments have demonstrated that the adsorption of the phage particle on the sensitive strains occurs only in a much more limited range of concentrations. We propose to explain this phenomenon in terms of the stability of colloids, considering the phage–bacteria suspension as a colloidal pool for which the fixation of the phage on the bacteria can occur only for 'flocculating' values of the ionic strength.

For this purpose, we use the stability theory of Verwey and Overbeek[7] with some modifications to take into account the differences in shape and charge between phage and bacteria. Finally, we arrive at the following expressions.

For the repulsive energy, V_r:

$$V_r = \varepsilon.a.\zeta_1.\zeta_2 \ln \{1 + \exp(-\varkappa.H_0)\}$$

in which ε is the dielectric constant of the medium, a is the equivalent radius of the phage, ζ_1 and ζ_2 the ζ-potentials of the phage and the bacteria respectively and H_0 is the shortest distance between the particles; and for the attractive energy, V_a:

$$V_a = \frac{-A.a}{6} \cdot \frac{1}{H_0}$$

in which A is the London–Van der Waals attraction constant. The reasons for adopting these formulæ have been described in detail elsewhere[6].

From these formulæ, we can obtain the total energy of interaction curves between phage and bacteria versus the distance H_0 between them. If, on the other hand, ionic conditions are allowed to change, a family of curves is then obtained. Fig. 1 shows such a family for the monovalent cations, and Fig. 2 that for the divalent ones. It is clear from these curves that, as soon as an energy barrier sufficiently high (greater than 10 kT as stated by Verwey and Overbeek) or sufficiently long (greater than 100 A.) exists, phage adsorption becomes impossible. This is fully confirmed by our experiments for all R-type bacteria, but not for the *F6 S* strain. The energy barrier vanishes progressively with increasing ionic

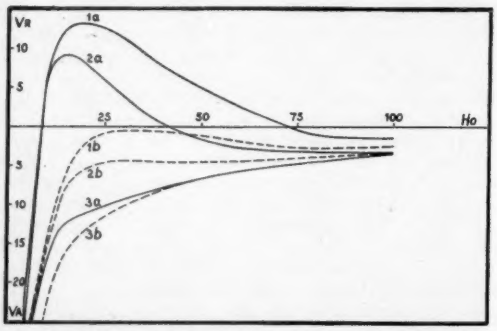


Fig. 1. Energy of interaction between phage and bacteria for various concentrations of monovalent ions. Abscissa: distance between phage and bacteria in angström units. Ordinate: energy of interaction expressed in multiples of kT. The repulsion energy is taken positively, the attractive one negatively. The full lines are for the R strains, the broken ones for the *F6 S*. Curves 1*a* and 1*b* correspond to $[Na^+] = 8 \times 10^{-2}$; curves 2*a* and 2*b* to $[Na^+] = 2 \times 10^{-2}$ and curves 3*a* and 3*b* to $[Na^+] = 8 \times 10^{-3}$

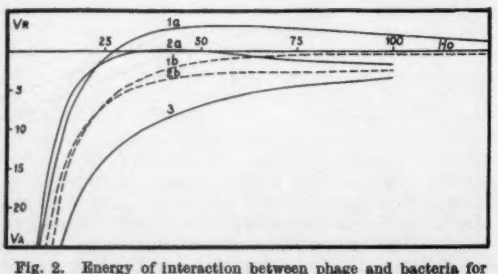


Fig. 2. Energy of interaction between phage and bacteria for various concentrations of divalent cations. Co-ordinates are the same as in Fig. 1.
Curves 1*a* and 1*b* correspond to $[Ca^{++}] = 4 \times 10^{-4}$; curves 2*a* and 2*b* to $[Ca^{++}] = 2 \times 10^{-2}$ and curve 3 to $[Ca^{++}] = 4 \times 10^{-2}$. In this last case, the curves for the S and R strains are so close together that they cannot be drawn separately

strength and phage adsorption becomes possible, which is in full agreement with experimental results for the *R* strains.

Two special cases, however, seem not to obey Verwey and Overbeek's theory.

The first one is concerned with the *F6 S* strain, for which fixation takes place only at high ionic concentrations despite the fact that no energy barrier exists at any of the ionic strengths tested. In other words, we can say that fixation of the phage on the *F6 S* strain occurs only when attraction predominates, as can be seen on the curves of Figs. 1 and 2. This suggests that another type of barrier must be present around these bacteria; for example, a mechanical one. We believe this mechanical barrier is formed by the superficial *S* antigen, this view being consistent with the fact that phage fixation on the *F6 S* strain requires an attractive energy of the same order of magnitude as that necessary for protein denaturation. The *S* strains seem, in a general manner, to show very anomalous electrochemical behaviour (unpublished work) and probably require a complete re-investigation according to their particular properties.

A second point that cannot be explained by the theory presented here is the inhibitory effect of cations at high concentration. Nevertheless, a relation seems to exist between the inhibitory effect of highly concentrated cations and the fraction of the bacterial surface occupied by them. As soon as this surface fraction becomes higher than 10–12 per cent of the total bacterial surface, no subsequent fixation occurs on the *R* strains. It may be suggested that, to explain the inhibition, the surface fraction occupied by the ions is not the sole determining factor but that the energy of binding of these ions to the bacterial surface, depending on the bacterial potential, must also be taken into consideration. If this is correct, it may be inferred that, on the *S* strain, a higher surface occupation will be tolerated before the inhibition takes place, because of the much smaller potential of these strains.

On this basis it was calculated that inhibition should begin for the *S* strain at a concentration as high as 4 *M* for the monovalent cations. This point seems to be experimentally confirmed.

For the divalent cations, inhibition would begin at 1 *M*, but this last point was impossible to investigate, the phage being destroyed too rapidly in these media.

The treatment of the inhibition with the aid of the statistical theory of the condensed state will give, perhaps, a better explanation of the experiments.

[1] Beumer, J., and Beumer-Jochmans, M. P., *Ann. Inst. Pasteur*, **89**, 394 (1955).
[2] Beumer, J., Beumer-Jochmans, M. P., and Dirkx, J., *Ann. Inst. Pasteur* (in the press).
[3] Puck, T. T., *Cold Spring Harbor Symp. Quant. Biol.*, **18**, 149 (1953).
[4] Beumer, J., Beumer-Jochmans, M. P., and Dirkx, J., *Ann. Inst. Pasteur*, **91**, 397 (1956).
[5] Puck, T. T., and Sagik, B., *J. Exp. Med.*, **97**, 807 (1953).
[6] Moyer, L. S., *J. Bacteriol.*, **32**, 433 (1936).
[7] Verwey, E. J. W., and Overbeek, J. T. G., "Theory of the Stability of Lyophobic Colloids" (Elsevier Pub. Co., 1948).
[8] Dirkx, J., Beumer, J., and Beumer-Jochmans, M. P., *Ann. Inst. Pasteur* (in the press).

LOCALIZATION OF RADIOACTIVE AND STABLE HEAVY NUCLIDES IN OCEAN SEDIMENTS

By G. ARRHENIUS and M. N. BRAMLETTE

Scripps Institution of Oceanography, La Jolla, California

AND

E. PICCIOTTO

Laboratoire de Physique Nucléaire, Université Libre de Bruxelles

A VARYING fraction of the sediment accumulating on the ocean floor consists of solids formed by precipitation from solution in the sea water, at the sediment surface, and in the sediment. Among these marine hydrogenous minerals are zeolites, manganite, goethite, barite and possibly some clay minerals, rutile and anatase. Also, a number of ionic species are transferred to the sediment by sorption in the molecular pores of the zeolites[1] and in the central layers of the manganites[2–4]. ('Manganite' is in this communication used as a chemical term, in accordance with Buser and coworkers[2]. The proper mineral name will be discussed elsewhere.) An extensive review of the distribution of rare metals in sedimentary rocks and an evaluation of the possible processes leading to this distribution have been published by Krauskopf[5]. There are few cases where the localization of trace elements in specific mineral constituents of fine-grained sedimentary rocks has been demonstrated directly.

The localization of trace metals in the minerals of ocean sediments is of special interest in the case of the naturally radioactive elements. The use of these elements for geochronological purposes depends largely on understanding the mechanism of transfer from the ocean to the sediment, and of redistribution following radioactive decay.

It is known that ionium (thorium-230) is at least partly separated from its predecessors in the ocean and carried to the ocean floor, where it generally gives rise to a high radium content. Several hypotheses have been advanced as to the mechanism of transfer of thorium from the ocean water to the sediment. Verification of any hypothesis by determining the localization of the thorium in particular constituents of the sediments has, however, been lacking, although Goldberg and Picciotto's finding[4] of a high thorium content in manganese nodules as well as Goldberg's theoretical considerations[5] point to the manganite as an important host mineral for this element.

Attempts to determine the ionium- and thorium-carrying minerals were started at Scripps Institution of Oceanography by E. D. Goldberg and us in 1954. Nuclear-emulsion techniques and β-counting demonstrated that most of the α- and β-activity from visible sources in the South Pacific sediments investigated was concentrated in authigenic crystals of

phillipsite[2]. Further investigations were carried out in the Institute of Nuclear Physics of the University of Brussels, using sediments from the North Equatorial Pacific with a low content of phillipsite. The distribution of α-activity was studied by autoradiographs of sections of sediment cores, and by suspension of sediment in liquid nuclear emulsion. The results of the suspension studies can be summarized as follows:

(1) The biogenous opal (mainly in the form of diatom frustules and radiolarian skeletons) is entirely inactive.

(2) 10 per cent of the α-tracks originate from small crystals (of the order 1μ) with a high refractive index. The specific activity of this mineral, which is possibly barite, is very high.

(3) 15 per cent of the activity occurs in aggregates with an average size of 3–10μ, frequently with a barium content exceeding 10 per cent and with densities ranging from 2·1 to 2·3. These aggregates may be fæcal pellets of benthonic animals.

(4) 25 per cent of the activity is associated with amber-coloured, fibrous fragments of widely varying size, mostly 20–100μ. The specific activity is of the order of 10^{-7} curie per gm. These fragments were afterwards demonstrated to consist of fibrous apatite and organic matter, and to be skeletal debris of fish.

(5) The remaining 50 per cent of the α-tracks do not originate from any visible solid sources, and are supposed to indicate radioactive matter in true or colloidal solution in the pore water of the sediment, or displaced from the solids of the sediment upon suspension in the photographic emulsion.

Subsequent analysis of skeletal fish debris from pelagic sediments of late Pleistocene to Recent age revealed that this material has a remarkable composition. In addition to the very high content of radioactive elements, there were found several per cent of the rare-earth elements, 0·6–1·5 per cent zinc, 0·1–0·5 per cent copper, 0·05–0·15 per cent tin and 0·03–0·10 per cent lead.

By separation of the organic phase of the fish debris from the apatite phase, it was demonstrated that the rare-earth elements and most of the strontium and barium occur in the apatite structure, whereas the organic phase contains the zinc, tin, lead, titanium, copper and silver, and much of the magnesium, aluminium, chromium and nickel.

Some of the bone and scale debris could be identified as derived from various genera of bathypelagic fish (Hubbs, Dr. Carl L., personal communication). One fragment appeared to be a part of a squid beak.

Analysis of the ashed residue of macerated bathypelagic fish caught by tow-net did not reveal any high concentrations of heavy metals, except for copper (0·03–0·04 per cent), zinc (0·01 per cent) and lead (0·005–0·01 per cent). These amounts, however, are considerably smaller than those found in the fossil debris. The concentration of heavy metals in the fish debris, therefore, appears to have taken place after the death of the organism. Fish debris from the top stratum of the sediment, corresponding to a time period of about the past ten thousand years, had already reached the same high concentration of heavy metals which is found in debris from Tertiary strata. It is thus evident that the concentration takes place in an early phase of the accumulation of the sediment. The measurements of the uranium, ionium, radium and thorium content of the fish debris have not yet been completed. Several facts suggest, however, that the high radioactivity of the Recent and Pleistocene fish debris is mainly due to thorium isotopes and their daughter products. The limitation of the highly alpha-active spots to the upper strata in the cores excludes the possibility of dominant uranium support; but, on the other hand, the active spots extend too far down to consist dominantly of unsupported radium. The high concentration of the rare-earth elements makes it highly probable that thorium, which has a geochemical behaviour similar to that of the rare-earth elements, is present in considerable amounts.

In a recent paper, Bowie and Atkin[6] have described skeletal material of Devonian fish with large amounts of associated uranium and especially thorium. In the case described, the uranium is mainly localized in the apatite structure, whereas the thorium is concentrated in the hydrocarbons which occur in the cavities of the bone structure. It is difficult at the present time to evaluate this finding in relation to the present observations on Cenozoic fish debris.

With long exposure on surfaces of especially low rate of accumulation, the biogenous apatite appears to dissolve at great ocean depth. The heavy-metal ions thus released seem to be resorbed in the secondary layer of the manganites, which are stable and offer a large active surface area. As a result, large amounts of thorium and rare-earth elements may be added to any already taken up in manganese nodules. In pelagic clays and oozes, where other components in addition to manganese micronodules contribute to a higher rate of accumulation, the fish debris is largely preserved, and the micronodules are lower in rare-earth elements.

Measurements of the crystallite size of marine apatites show a relation (that may be direct or indirect) of this parameter to the rare-earth content. The bathypelagic fish debris has a crystallite size of 300–400 A. along the Z-axis and has a rare-earth content as high as a few per cent. Whale bone fragments, exposed under similar conditions on the deep ocean bottom, but with a crystallite size of 600–1200 A., have a rare-earth content of the order of 0·1 per cent. Marine inorganic apatites, with crystallite sizes greater than 20,000 A., contain a total of rare earths of only 0·05 per cent or less.

It thus seems that ionium, produced from uranium-234 in solution in sea water, together with other thorium isotopes, the rare-earth elements and a number of other heavy metals, is carried to the sediment and sorbed to the surface of the microcrystalline apatite of skeletal debris. If a solid carrier is involved, this may not necessarily be the apatite itself but some other unidentified solid, such as organic matter, which is later dissolved. The details of these processes, as well as the redistribution of radium formed by the decay of ionium, are being further investigated, and a more extensive account of the results will be given on completion of the first phase of the work.

Support for this investigation was received from the Geological Society of America and the Office of Naval Research.

[1] Arrhenius, G., and Goldberg, E., *Tellus*, **7**, 226 (1955).
[2] Buser, W., and Grütter, A., *Schweiz. Min. u. Petr. Mitteil.*, **36**, 49 (1956).
[3] Goldberg, E., *J. Geol.*, **62**, 249 (1954).
[4] Goldberg, E., and Picciotto, E., *Science*, **121**, 613 (1955).
[5] Krauskopf, K., *Econ. Geol.*, **50**, 411 (1955); *Geochim. Cosmochim. Acta*, **9**, 1 (1956).
[6] Bowie, S., and Atkin, D., *Nature*, **177**, 487 (1956).

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

Electron Micrographs of Cross-Sections of Protein Monolayers

ELECTRON micrographs of cross-sections of protein monolayers have been obtained in the following way. A monolayer of protein, a commercial sample of egg albumen, was spread at the surface of water contained in a small Langmuir type trough. This layer was then compressed and crumpled by advancing a barrier coated with paraffin wax towards a second retaining barrier. When the two barriers were about a centimetre apart, the crumpled film became visible at the interface and was lifted from the water as a frail thread by means of a wire yoke. Portions of this thread were prepared for cross-sectioning by dehydrating in an alcohol series and embedding in an epoxide resin[1]. It was found advantageous to 'stain' the specimen first by treating it for a short time in a buffered osmium tetroxide solution. The thread, darkened and hardened by this treatment, was easier to handle and to see by eye in the block and also in the electron microscope. Very thin sections were cut from the block at right angles to the length of the thread by the standard procedure for electron microscopy[2] and examined in a Siemens 'Elmiskop I' microscope.

The cross-section of the crumpled sheet of protein appeared as a thin, dense, highly convoluted line (Fig. 1). Since the thickness of the best sections (about 200 A.) was still some ten times that of the monolayers (10–20 A.), it was not expected that the films viewed end on would everywhere reveal their true thickness. The thinnest portions observed in osmium-fixed material were in fact about 50 A. thick, and some of these appeared double, suggesting either that the osmium was deposited on each side of the protein film or that more than a simple monolayer was present. Occasionally a contaminating layer was seen adsorbed on one side of the film and pinched-off tubules usually enclosed amorphous material which may have been excess protein.

Fig. 1. Electron micrograph of a cross-section of a crumpled monolayer of egg albumen stained with osmium tetroxide

This work is part of an attempt to prepare artificial models of cell membranes. Multiple layers and tanned layers are also being examined. It is remarkable how closely some of the chance structures in these crumpled films resemble sections seen in electron micrographs of such organelles as the mitochondrion and the Golgi complex.

The work has been supported by grants to the Chester Beatty Research Institute (Institute of Cancer Research: Royal Cancer Hospital) from the British Empire Cancer Campaign, the Jane Coffin Childs Memorial Fund for Medical Research, the Anna Fuller Fund, and the National Cancer Institute of the National Institutes of Health, U.S. Public Health Service. I am indebted to Dr. R. J. Goldacre for many suggestions.

E. H. MERCER

Chester Beatty Research Institute
(Institute of Cancer Research:
Royal Cancer Hospital),
London, S.W.3.
May 13.

[1] Glauert, A. M., Rogers, G. E., and Glauert, R. H., *Nature*, **178**, 803 (1956).

[2] See accounts given in Proceedings of the International Conference on Electron Microscopy, London 1954 (1956).

Ion Cyclotron Resonance

A CHARGED particle of mass m and charge e crossing a uniform magnetic field of strength H will describe a circular path with angular frequency $\omega = eH/mc$, independently of the particle's energy (c is the velocity of light). If such a particle is subjected to an alternating electric field, at the cyclotron frequency, perpendicular to the magnetic field, then absorption of energy from the electric field may be expected. A measurement of the frequency at which absorption takes place should therefore enable the mass of the resonating particle to be determined, given e, H and c, while the amount of absorption should provide information on the number of resonating particles present.

This technique has previously been successfully applied at frequencies corresponding to the electron cyclotron resonance, but so far has not been reported at frequencies corresponding to positive-ion cyclotron resonances in an ionized gas or plasma.

Recently, in this Laboratory, an experiment was performed with the object of detecting the cyclotron resonance for the positive ions in a discharge in hydrogen. A discharge was established in a tube containing hydrogen at low pressure, and a radial electric field at a frequency of about 750 kc./sec. was applied to the plasma. The tube was immersed in a longitudinal uniform magnetic field of approximately 500 gauss, superimposed on which was a sinusoidal magnetic field of amplitude of the order of 10 gauss at a frequency of 50 cycles/sec.

The resonance was detected by displaying the rectified signal, obtained from electrodes external to the tube, on a cathode-ray tube which was scanned at a frequency of 50 cycles/sec. On this cathode-ray tube a 'pip' was observed which behaved, with

variation of frequency and of the modulation of the magnetic field, in the manner to be expected from a resonance. It is thought, therefore, that the absorption corresponded to the cyclotron resonance of the hydrogen atomic ions in the discharge. An attempt to detect the absorption corresponding to the cyclotron resonance of hydrogen molecular ions in the discharge was defeated by noise from the discharge.

Work to measure the characteristics of the resonance for various gases is in progress.

R. F. Saxe

Nuclear Engineering Laboratory,
Queen Mary College
(University of London),
Mile End Road,
London, E.1.
May 14.

Excited Levels in Arsenic-75 produced by Radiative Capture of Protons by Germanium-74

Discrete energy-levels have been observed in arsenic-75 at excitation energies between about 8·0 and 10·0 MeV. The experimental procedure was as follows. Targets of separated germanium-74 of thickness 100 μgm./cm.² and 10 μgm./cm.² deposited on tungsten backings (prepared at the Atomic Energy Research Establishment, Harwell) were irradiated by the proton beam from a pressurized electrostatic generator[1], and the γ-rays emitted were detected by means of a thallium-activated sodium iodide crystal 36 mm. diameter by 25 mm. long coupled optically to a photomultiplier of type 6262*A*. The output from the photomultiplier was fed into a scaler via a cathode follower and linear amplifier of type 1008.

The energy of the incident proton beam was measured to an absolute accuracy of better than one part in a thousand, using an electrostatic analyser[2]. Care was taken to avoid the deposition of carbon on the target surfaces by placing a liquid-nitrogen trap immediately in front of the target, and ensuring that the target temperature did not fall below 200° C. during the irradiation[3].

The background due to the tungsten backing was estimated by irradiating a tungsten foil, and an approximate value for the cross-section of the $^{74}Ge(p\gamma)^{75}As$ reaction was obtained by comparing the yield with that from the 1·348 MeV. resonance in the $^{19}F(p\gamma)^{16}O$ reaction, using the same detection geometry and a calcium fluoride target of known thickness.

A total of twenty-five γ-emitting resonances was observed for protons in the energy-range 1·0–2·7 MeV. These are listed with half-width measurements in Table 1, and the yield curve is shown in Fig. 1. These measurements were all obtained on the 10 μgm./cm.² target, the thickness of which, in energy units, was equal to between 1 and 2 keV. Corrections for target thickness have been made to the resonance values,

Table 1

Resonant energies (MeV.)	Half-widths (keV.)	Arsenic-75 excitation energies (MeV.) 6·83 + 0·15
1·006	< 2·5	+0·993
1·094	9·5	1·079
1·167	4·5	1·151
1·213	< 2·5	1·188
1·257	< 2·5	1·240
1·332	5·0	1·314
1·422	< 2·5	1·403
1·530	9·0	1·510
1·559	6·5	1·538
1·643	~ 15	1·621
1·665	~ 15 incompletely resolved	1·642
1·690	~ 30	1·667
1·805	20	1·781
1·906	~ 15 incompletely resolved	1·881
1·926	~ 15	1·900
1·972	35	1·946
2·074	13·5	2·047
2·161	~ 15	2·132
2·210	40	2·181
2·295	27	2·264
2·342	15	2·310
2·440	11	2·407
2·528	15	2·495
2·593	44	2·559
2·664	10	2·629

which are accurate on the absolute energy scale to ± 2 keV. or better. The correction for the contribution due to target thickness[4] introduced large uncertainties in the estimation of the natural half-widths of some of the narrower resonances, and where this occurred, the measured half-widths have been given as an upper limit. Some uncertainty also occurs in the estimation of the half-widths of incompletely resolved resonances, and the values given may be in error by as much as ± 20 per cent.

From isotopic mass measurements given by Wapstra[5], the *Q* value for the $^{74}Ge(p\gamma)^{75}As$ reaction is calculated to be 6·83 ± 0·15 MeV. The competing reaction $^{74}Ge(p\alpha\gamma)^{71}Ga$ is calculated to have a *Q* value of 1·38 ± 0·2 MeV., and this may also be accompanied by γ-emission. The $^{74}Ge(pn)^{74}As$ reaction is

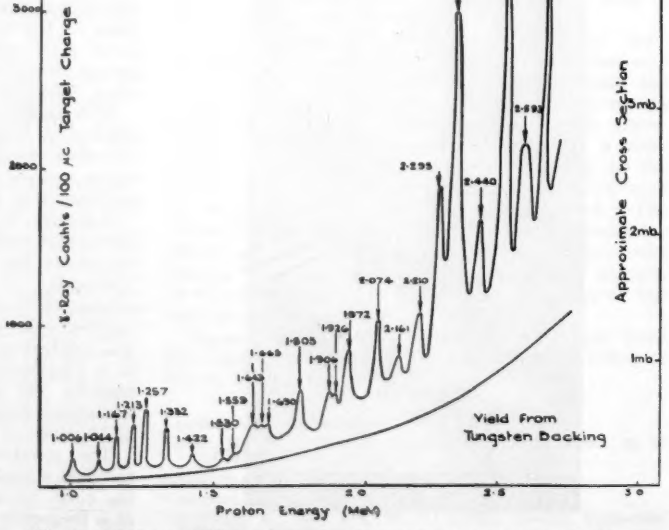


Fig. 1. Gamma-ray yield from 10 gm./cm.² germanium-74 target irradiated by protons

calculated to have a threshold of about 3·8 MeV. No search has yet been made for α-particle emission, but a preliminary search for neutron emission, using a boron trifluoride counter with paraffin wax moderator, has failed to detect the presence of neutrons, and no activity of long life corresponding to the formation of arsenic-74 has yet been observed on the irradiated targets.

D. R. Chick
S. E. Hunt

Research Laboratory,
Associated Electrical Industries, Ltd.,
Aldermaston, Berkshire.
March 21.

[1] Chick, D. R., and Petrie, D. P. R., *J. Inst. Elect. Eng.*, B, **103**, 8, 132 (1955).
[2] Hunt, S. E., Petrie, D. P. R., Firth, K., and Trott, A. J., *J. Inst. Elect. Eng.*, B, **103**, 146 (1955).
[3] Hunt, S. E. *Proc. Phys. Soc.*, **65**, 982 (1952).
[4] Tangen, R. K., *Norske Vidensk Selsk.*, Skr. No. 1 (1946).
[5] Wapstra, A. H., *Physica*, **21**, 5, 385 (1955).

X-Ray Radiation Hazard using Vacuum Deposition Plant

It has been shown in a recent report by Strachan and Harris[1] that a sputtering plant operated at voltages as low as 8–10 kV. can give rise to X-radiation which can be dangerous to the operator. This observation was made with an apparatus different from the two-electrode system used for the deposition of thin films. Their apparatus consisted of a glass vessel in which positive ions formed in a discharge between an oxide-coated cathode and iron anode were accelerated to a target used for sputtering. It was shown that the X-rays arose from secondary electrons emitted from the target bombarding the walls of the glass envelope. It was possible to operate the main sputtering chamber at a lower gas pressure than normal because the ions were formed in an auxiliary discharge. Thus, the secondary electrons were able to reach voltages comparable to that of the ion-accelerating potential because of their long mean free-path. In a glow discharge the secondary electrons are required for ionizing the gas molecules and their final voltage is not that of the applied potential. Thus it is uncertain whether the results of Strachan and Harris would be directly applicable to a normal two-electrode system with a cold cathode operated at 8–10 kV.

Since the above report was published, I have received several queries as to whether X-radiation is emitted from normal vacuum deposition plant, and after discussion with workers at the Research Laboratories, General Electric Co., Ltd., it was decided to make radiation tests to ensure that such apparatus was safe. Radiation tests were made with Ilford *PMI* film in standard monitor holders using different types of deposition apparatus as described below.

It should be noted that the voltages given below for both the a.c. and d.c. high-tension supplies are root-mean-square values and the peak voltage encountered will be about 1·4 times the quoted values.

Initial tests were made with a cathodic sputtering apparatus and an electron-bombarded vapour source operating at voltages up to 4 kV. inside metal vessels with observation ports of plate-glass 9 mm. thick. In neither case did the monitor film show X-ray exposure after ten hours operation.

Work was then extended to apparatus operating at higher voltages inside glass vessels, such as that used for ionic-bombardment cleaning of glass before evaporation of thin films. At one time it was customary to use for this purpose high-reactance transformers giving some 10 kV., and as the discharge approached the 'blackout' condition the applied voltage rose to nearly the open-circuit value. In the vacuum apparatus at present designed by this Company, the maximum voltage used is 5·5 kV. and this is within the safe limit found by Strachan and Harris. However, it was of interest to know whether early vacuum plants were free from hazard.

A high-tension transformer giving 10 kV. open-circuit voltage was connected to two vertical electrodes insulated from earth and made from aluminium strip inside a 'Pyrex' bell-jar 18 in. diameter by 24 in. high. The wall thickness of the vessel was about 8 mm. Two test films were placed on the side of the vessel and one at a distance of 6 in. from the vertical side. The glow discharge was operated at 7 kV. and 8 m.amp. for 11½ hr. without X-ray exposure being observed. Two 10-kV. transformers were then connected with their output terminals in series and the apparatus again run for 8 hr. at 18–20 kV. and 20 m.amp. Again no X-ray hazard was observed.

Mr. Ball (G.E.C.), who kindly examined the monitoring film used in these tests, considers that if X-radiation was being generated then the energy was insufficient to penetrate the chamber walls. He states that a voltage of about 16 kV. is necessary for X-rays to penetrate 8-mm. thick 'Pyrex' glass in measurable quantities. This voltage would, of course, refer to electrons which struck the target, etc., with an energy equal to the applied potential, as must have occurred in the apparatus of Strachan and Harris, or could occur in thermionic devices operated at low gas pressures (for example, an electron-bombarded vapour source).

Acknowledgments are made to the Research Laboratories, General Electric Co., Ltd., for the help given in the tests and to Mr. A. S. D. Barrett, technical director of Edwards High Vacuum, Ltd., for permission to publish this communication.

L. Holland

Research Laboratory,
Edwards High Vacuum, Ltd.,
Crawley, Sussex.
May 10.

[1] Strachan, J. F., and Harris, N. L., *Nature*, **178**, 588 (1956).

Thallium-activated Sodium Chloride Recrystallization Phosphors

Investigations have been carried out with sodium chloride disks prepared in a pressure-range of 1,000–20,000 kgm./cm.^{2}. A few drops of an aqueous solution of thallium chloride were mixed with the sodium chloride powder before pressing. After ultra-violet excitation, the disks showed a good phosphorescence with a decay time of several minutes. The measurements were carried out with an *RCA* multiplier-tube type 931*A* and galvanometer.

Earlier optical and conductivity measurements showed that recovery takes place after the disks had been prepared. This recovery process can also be observed with the luminescent disks: the total light radiated gradually decreases with time.

After heat treatment of the luminescent disks, the total light radiated decreases with increasing tem-

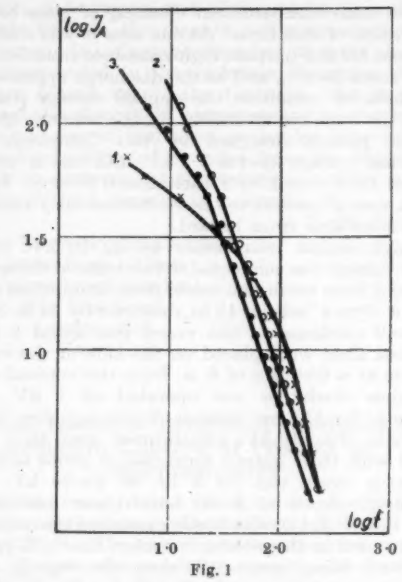


Fig. 1

perature (up to 300° C.) and then (300–600° C.) again increases.

In the case of thallium-activated sodium chloride disks, decay did not follow the well-known exponential law of thallium-activated sodium chloride single crystal phosphors. The shape of the brightness versus time curve is satisfactorily accounted for by a hyperbolic expression. Experiments were carried out with thallium-activated sodium chloride single-crystal phosphors grown from the melt. These crystals showed an exponential decay law; however, after the crystals had been deformed by stressing, the exponential law changed to a hyperbolic one (Fig. 1). When the decay of the phosphorescence is represented in a (log–log) diagram, as in Fig. 1, the exponential decay law is represented by curve 1, while the shape of the diagram becomes a straight line after the stress had been applied (curves 2 and 3). Hence it seems that dislocations may seriously affect the decay of phosphorescence.

A detailed account of this work will be published elsewhere. I wish to thank Prof. Z. Gyulai, who directed the investigation.

Z. Morlin

Institute of Experimental Physics,
Budapest University of Technology.

Reaction of Nitrates with Liquid Sulphur Dioxide

It has been known for some time that inorganic nitrates catalyse the formation of polysulphones from liquid mixtures of olefines and sulphur dioxide[1], but the mechanism of catalysis has never been clarified. It is now suggested that the effective catalyst is nitrogen dioxide and/or the sulphite radical ion formed as the primary products of the reaction between nitrates and sulphur dioxide. The following observations are consistent with this suggestion:

(1) If sufficient silver nitrate is allowed to react with liquid sulphur dioxide, a brown gas appears but may, in time, disappear again. The brown gas is presumably nitrogen dioxide formed by processes such as $NO_3^- + SO_2 \rightarrow NO_2 + SO_3^-$, $NO_3^- + SO_3^- \rightarrow NO_2 + SO_4^{2-}$, and removed by further reactions with sulphur dioxide. In the presence of excess sulphur dioxide, the final products are likely to be nitrosyl pyrosulphate and nitric oxide[2], the overall reaction being:

$$6\,MNO_3 + 7\,SO_2 = 3\,M_2SO_4 + 2\,(NO)_2S_2O_7 + 2\,NO$$

It is worth noting that rapid oxygen atom transfer reactions such as $ClO_2^- + SO_3^{2-} \rightarrow ClO^- + SO_4^{2-}$ have been recognized[3].

(2) The observation of Dainton and Ivin[4] that the volatile products of the silver nitrate – sulphur dioxide reaction did not catalyse polysulphone formation is now consistent with this picture. Previously they had supposed that nitrogen dioxide was the end product.

(3) The only three completely soluble nitrates investigated by Snow and Frey[1] as catalysts for polysulphone formation were those of lithium, silver and ammonium, the efficiency increasing in that order. In liquid sulphur dioxide (dielectric constant 15·6 at 0° C.) the Bjerrum critical distance[5] for ion-pair formation is calculated to be 19·6 A. at 0° C. and it is to be expected that even with nitrate concentrations of 10^{-4} M there will be a considerable degree of association of the ions. Hence the rate-determining step for the initiation of polysulphone formation should probably be written as:

$$M^+NO_3^- + SO_2 \rightarrow M^+ + NO_3 + SO_3^-$$

The cation would be expected to affect the ease of release of the oxygen ion, and it is interesting to note that the catalytic efficiency increases with increasing size of the (crystallographic) cationic radius.

(4) Nitrogen dioxide is known to attack olefines[6]. The sulphite radical ion may equally well be the effective catalyst, since it has been shown to initiate the polymerization of styrene[7].

Attempts were made to follow the variation of the nitrogen dioxide concentration with time spectrophotometrically in mixtures of sulphur dioxide with ammonium or silver nitrate. These experiments were not successful, because of the very low solubility of the nitrates.

I thank Prof. F. S. Dainton for his interest in this work.

K. J. Ivin

Department of Physical Chemistry,
University of Leeds.
March 26.

[1] Snow, R. D., and Frey, F. E., *Indust. Eng. Chem.*, **30**, 176 (1938).
[2] Manchot, W., and Schmid, H., *Ber.*, **62B**, 1261 (1929).
[3] Halperin, J., and Taube, H., *J. Amer. Chem. Soc.*, **74**, 375 (1952).
[4] Dainton, F. S., and Ivin, K. J., *Proc. Roy. Soc.*, A, **212**, 96 (1952).
[5] Robinson, R. A., and Stokes, R. H., "Electrolyte Solutions", 331 (Butterworths, 1955).
[6] Gray, P., and Yoffe, A. D., *Quart. Rev.*, **9**, 371 (1955).
[7] Sully, B. D., *J. Chem. Soc.*, 1498 (1950).

Interference in Soil Phosphorus Analyses by Snail Shells

In some calcareous grassland soils in County Galway, certain fertility problems have been encountered with particular regard to soil phosphorus. While 'high' or 'very high' values for readily soluble phosphorus were sometimes obtained by routine analytical procedures[1], grazing and botanical observations indicated extreme phosphorus deficiency. Such

Table 1. VARIATIONS IN 'READILY SOLUBLE' PHOSPHORUS (USING MORGAN'S SOLUTION) IN SOIL CORES CONTAMINATED WITH SNAIL SHELLS

Core No.	Separate phosphorus extractions with Morgan's solution				
	1	2	3	4	Mean
	p.p.m.	p.p.m.	p.p.m.	p.p.m.	p.p.m.
1 (0–2 in.)	2·5	2·5	2·8	5·3	3·3
1 (2–5 in.)	5·3	2·5	4·0	2·0	3·5
2 (0–2 in.)	9·5	2·8	2·8	5·5	5·2
2 (2–5 in.)	5·3	3·3	3·5	6·8	4·7
3 (0–2 in.)	10·5	10·5	5·3	5·5	8·0
3 (2–5 in.)	10·5	3·5	15·0	7·0	9·0
4 (0–2 in.)	5·0	3·5	6·0	6·8	5·3
4 (2–5 in.)	4·5	9·5	7·0	4·5	6·4
Surface shells	372	450	450	472	436

observations were verified by herbage analyses, where figures of the order of 0·10–0·11 per cent of the dry matter were obtained.

While investigating the above anomaly, it was observed that considerable quantities of small snail shells in varying stages of decomposition had become admixed with the soil in the problem areas. The predominant species have been identified as (1) *Helicella itala* (Linn.)—a circular shell of approximately ½ in. diameter, and (2) *Helicella aspera*—a turret or spiral-shaped shell ⅛ in. in diameter at the open end. The former, as is consistent with their life-history, were found at or just underneath the soil surface, while the latter were almost invariably found to have penetrated more deeply. While there was little evidence of either species during winter or spring, there was a striking appearance during the July–August period, when as many as ten per square yard was quite a common feature in certain areas, particularly in the vicinity of the outcropping limestone rocks.

Chemical analyses[1] showed levels as high as 3,200 p.p.m. total phosphorus in surface shells, while subsurface shells contained 900–1,000 p.p.m. total phosphorus. This indicated a likely source of phosphorus contamination during soil sampling. To ascertain the resultant effect on routine chemical analyses, four cores of soil, each 3 in. in diameter and 5 in. in depth, were extracted from a typical area in close proximity to one another. Each core was subdivided into 'surface' (0–2 in.) and 'subsurface' (2–5 in.) samples. Four subsamples of each were extracted with Morgan's solution using a 5 : 1 extractant/soil ratio. The results are shown in Table 1 and are contrasted with samples of surface shells which were ground up and treated as soils.

Table 1 shows considerable variation in the quantity of phosphorus released, not only from the different cores removed from contiguous positions in the field, but also an important difference even in the subdivided cores themselves. It is likely that this inconsistency is due to the contamination of readily extractable phosphorus which the shells contain. It should be pointed out that 'surface shells' (Table 1) refers to both the snail and the shell. An analysis of the shells alone showed a phosphorus level of 168 p.p.m. with Morgan's solution, which may be considered as entirely calcium-bound phosphorus.

Thus considerable soil sampling problems are posed in areas where snail infestations occur to the extent reported here. I wish to acknowledge the helpful assistance of the Department of Zoology, University College, Dublin, for information on the identification and life-history of the *Helicella* spp.

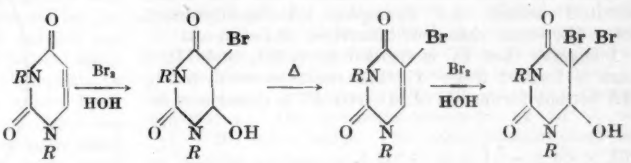
P. M. McDONNELL

Department of Agriculture,
Johnstown Castle,
Wexford, Ireland.
March 23.

[1] Muir, J. W., *The Analyst*, **77**, 313 (1952). Walsh, T., Ryan, P. F., and McDonnell, J. J., *Trans. Int. Soc. Soil Science* (Dublin), **2** (1952).

Reaction of Bromine with Uracils

SOME interesting observations on the reaction of bromine with pyrimidine compounds were recently reported by Cohn[1]. Since 1907, when Wheeler and Johnson[2] first observed the coloured reaction product obtained by the action of bromine with uracil or cytosine and isolated the intermediate, the bromine reaction has been utilized for structural determinations, analyses and the preparation of derivatives[3]. In 1940, Johnson concluded that "5,5-dibromo-4(6)-hydroxyhydrouracil decomposed spontaneously and quantitatively to 5-bromouracil and HOBr"[4]. I have been unable to confirm this observation. Due to the renewed interest in pyrimidine chemistry and the discrepancies concerning the bromine reaction which have appeared in the literature, I wish to propose a mechanism for this reaction based on the experiments described below.



(I) (II) (III) (IV)

(*A*) R = H; (*B*) R = CH_3

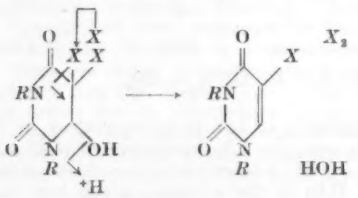
The addition of one mole equivalent of bromine water to uracil or 1,3-dimethyluracil resulted in the formation of 5-bromo-6-hydroxyhydro-derivatives (II*A* or II*B*) in the solution, which lost its ultraviolet spectrum[5]. However, on standing or heating, 5-bromouracil (III*A*, found : Br, 41·51 ; N, 14·81 per cent ; λ(H_2O max.) 276 mμ, ε 7·2 × 10^3 ; λ250/λ260, 0·55 ; λ280/λ260, 1·47) or 5-bromo-1,3-dimethyluracil (III*B*)[5] was formed. The dehydration proceeded spontaneously and quantitatively and thus provided an excellent method for the preparation of III. When a second mole equivalent of bromine was added to III*A* or III*B*, 5,5-dibromo-6-hydroxyhydrouracil (IV*A*, found : Br, 54·05 per cent, crystallized from water, $C_4H_4N_2Br_2O_3$. $\frac{1}{2}H_2O$; melting point, 210° ; found : Br, 55·12 per cent, crystallized from acetone–petroleum ether ; melting point, 210°) or 5,5-dibromo-6-hydroxy-1,3-dimethylhydrouracil (IV*B*, found : Br, 49·15 per cent, crystallized from water ; $C_6H_8O_3N_2Br_2$. $\frac{1}{2}H_2O$; melting point, 136–37° ; found : Br, 50·5 per cent, crystallized from acetone–petroleum ether, melting point 139–40°) was formed.

IV*A* and IV*B* in aqueous solution (2×10^{-2} *M*) were refluxed for eight hours or more and gave at 275 mμ, ε $3·9 \times 10^3$ and 280 mμ, ε $3·4 \times 10^3$ respectively, thus indicating about 50 per cent con-

version to III*A* and III*B*. These were confirmed by the isolation and identification of III*A* (λ250/λ260, 0·54; λ280/λ260, 1·45; and III*B* (mixed melting point, 184–85°, λ250/λ260, 0·48; λ280/λ260, 0·25). This suggested that hydrogen bromide, resulting from the hydrolysis of IV*A* and IV*B*, catalysed the formation of III*A* and III*B*. When IV*A* and IV*B* were refluxed for 24 hr. or more at a concentration of 1×10^{-4} *M*, no increase in ultra-violet absorption at any time was observed. However, when the reaction was carried out in 2 *N* hydrochloric acid or 2 *N* hydrobromic acid, the absorption at 280 mμ gradually increased to more than 80 per cent of that for III*A* and III*B* at the end of 8 hr. These observations indicate that III is formed from IV only when H*X* is present, and I cannot wholly agree with the following statement made by P. A. Levene[3]: "The original product which forms immediately on addition of (excess) bromine (to uracil) is undoubtedly 5,5-dibromo-4(6)-hydroxhydrouracil. This compound is then transferred into 5-bromouracil".

Since most workers have been under the impression that IV is highly unstable (which belief now appears untenable), they used the method of Levene[6] for the preparation. This method requires the addition of bromine until the colour of the solution remains permanently yellow. However, I observed that if the reaction is carried out at or below room temperature, the yellow colour appears after one mole equivalent of bromine has been added. Thus the isolation of IV is not possible under these conditions. I found that the uracil derivatives and the 3-substituted uracils, for example, 1,3-dimethyluracil, show the same chemical behaviour throughout.

I suggest that IV is formed from III, and III in turn is formed from II. The reaction catalysed by H*X* for the formation of III from IV is illustrated as:



The detailed results of the work and the lability of IV in weak base together with the formation of 5-hydroxyuracils from their corresponding 5-bromouracils will be reported elsewhere. The work was done under the terms of Contract *AT*(30–1)–911 of the Physiology Department, Tufts University School of Medicine, with the Atomic Energy Commission. I thank Margarita Apicella and Ruth Weintraub for their technical assistance.

Shih Yi Wang

Department of Physiology,
Tufts University School of Medicine,
136 Harrison Avenue,
Boston 11, Mass.
Feb. 12.

[1] Cohn, W. E., *Biochem. J.*, **64**, 28*P* (1956).
[2] Wheeler, H. L., and Johnson, T. B., *J. Biol. Chem.*, **3**, 183 (1907).
[3] Levene, P. A., "Nucleic Acids", Amer. Chem. Soc. Monograph No. 56, p. 54 (Chemical Catalog Co., Inc., New York, 1931).
[4] Johnson, T. B., *J. Amer. Chem. Soc.*, **62**, 2269 (1940).
[5] Wang *et al.*, *J. Amer. Chem. Soc.*, **78**, 4180 (1956) for proof of structures.
[6] Levene, P. A., *J. Biol. Chem.*, **63**, 683 (1925).

A Modified Nagler Medium

Hayward[1] suggested in 1941 that the Nagler reaction might be used for the rapid identification of *Clostridium welchii*. She expanded this work later[2] and directed attention to the difficulty of distinguishing between *Cl. welchii* and *Clostridium bifermentans* on serum agar plates. Both these organisms produced opalescence in the medium, and it was inhibited by *Cl. welchii* antitoxin. She suggested that distinction between these organisms may be made by making use of the hydrolysis of phenolphthalein phosphate as described by Bray and King[3].

Since *Cl. welchii* is a lactose-fermenting anaerobe and *Cl. bifermentans* is a non-lactose fermenter, the incorporation of lactose and neutral red into the Nagler medium should provide a means of distinguishing between them on a single plate culture.

A modified Nagler medium using egg-yolk instead of serum was therefore prepared in a meat infusion agar base[4], to which was added 1 per cent lactose and 0·03 per cent neutral red. Plates of this medium were spread on one half with *Cl. welchii* type *A* antitoxin, inoculated and incubated anaerobically.

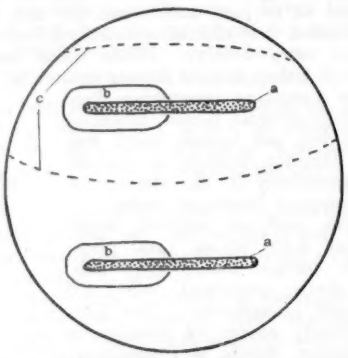


Fig. 1. Diagram of plate cultures of *Cl. welchii* (upper half) and *Cl. bifermentans* (lower half) on the half-antitoxin egg-yolk lactose medium. Antitoxin on right half of plate. (*a*) Streak culture of organism; (*b*) zone of opalescence; (*c*) limits of red halo

Preliminary trials with a number of strains of *Cl. welchii* types *A* to *E* and *Cl. bifermentans* have shown that distinction between these organisms on this medium is readily made (Fig. 1). *Cl. bifermentans* produces opalescence which is inhibited by *Cl. welchii* type *A* antitoxin. *Cl. welchii* types *A–E*, in addition to producing opalescence which is inhibited by antitoxin, also produces a distinct pink or red halo in the medium surrounding the opalescence zone. This red zone is due to acid produced by fermentation of the lactose. All strains of *Cl. welchii* and *Cl. bifermentans* so far tested have consistently produced the reactions described, and a diagnosis could be made in all cases after anaerobic incubation for 12–18 hr. Since *Cl. welchii* is the only lactose-fermenting clostridium which produces lecithinase, the production by an anaerobe of opalescence inhibited by *Cl. welchii* type *A* antitoxin together with a red halo is diagnostic of *Cl. welchii*. The medium should therefore be of value in detecting *Cl. welchii* in mixtures with other organisms.

Further investigations along these lines are at present being made and will form the basis of a subsequent communication.

A. T. Willis
G. Hobbs

School of Medicine,
University of Leeds,
Leeds 2.
March 25.

[1] Hayward, Nancy J., *Brit. Med. J.*, i, 811, 916 (1941).
[2] Hayward, Nancy J., *J. Path. Bact.*, **55**, 285 (1943).
[3] Bray, J., and King, E. J., *J. Path. Bact.*, **54**, 287 (1942).
[4] Reed, G. B., Dubos's "Bacterial and Mycotic Infections of Man", 1st ed., 357 (Lippincott, Philadelphia, 1948).

Proteolysis of Collagen

It was shown by Linderstrøm-Lang and co-workers[1] that the tryptic hydrolysis of β-lactoglobulin involves the reversible denaturation of the protein as a preliminary stage. A consideration of known facts, together with new evidence obtained in connexion with an investigation of the mechanism of bating of skins in leather manufacture[2], indicates that collagen and procollagen are also denatured by the enzyme prior to hydrolysis. Bating is a process in which skins, after liming and deliming, are treated with a proteolytic enzyme (usually trypsin) in order to produce a soft leather. The process has been shown to involve the removal of degraded collagen (a form of collagen in which the fibrillar structure has disintegrated and which has been named 'progelatin'[2]) produced by the swelling action of lime, and is normally carried out at about 37° C. Temperature control is critical since little or no action takes place below 35° C., and above 40° C. rapid digestion of intact collagen occurs, leading to a loss of leather-making substance. The lower limit is explained by the fact that progelatin must be converted into gelatin before it can be hydrolysed by the enzyme. If, however, the skin is heated to 40–45° C. before adding the enzyme, bating can be carried out at a much lower temperature, for example, at 27° C. in about twice the time required at 37° C., which is in accord with the temperature coefficient of proteolytic enzymes acting on gelatin[3]. The higher temperature required to heat the progelatin in the absence of enzyme than in its presence is indicative of a denaturation stage which can be catalysed by the enzyme. As denaturation is believed to involve rupture of hydrogen bonds between parallel molecular chains, the enzyme functions as a hydrogen bond breaker in a similar manner to chemicals such as alkali, urea, potassium thiocyanate, etc.

Hydrogen bond breaking by chemicals can be followed by the decrease in hydrothermal shrinkage temperature (T_s), but fails with proteolytic enzymes since denaturation is immediately followed by hydrolysis, so that shrinkage does not occur. It is impossible to wash out completely or inactivate the enzyme adsorbed on the collagen, which is remarkably stable so that even plunging the enzyme-treated collagen into boiling water results in appreciable hydrolysis before the enzyme is inactivated[4]. Any chemical treatment that lowers the T_s of collagen results in an increased rate of attack by trypsin at 37–40° C. because the activation energy for enzyme denaturation is reduced. Various native fish collagens are attacked by trypsin at temperatures related to their hydrothermal shrinkage temperatures[5]. Fish collagens are believed to differ from mammalian collagen principally in the degree of hydrogen bonding[6] and so behave similarly to chemically treated mammalian collagen.

G. H. Green

British Leather Manufacturers' Research Association,
Milton Park,
Egham, Surrey.
March 22.

[1] Linderstrøm-Lang, K., Hotchkiss, R. D., and Johansen, G., *Nature*, **142**, 996 (1938). Christensen, L. K., *ibid.*, **163**, 1003 (1949). Linderstrøm-Lang, K., *Cold Spring Harbor Symp. Quant. Biol.*, **14**, 117 (1950).
[2] Green, G. H., *J. Soc. Leath. Trades Chem.* (in the press).
[3] Green, G. H., *J. Soc. Leath. Trades Chem.*, **40**, 369 (1956).
[4] Neuman, R. E., and Tytell, A. A., *Proc. Soc. Exp. Biol. N.Y.*, **73**, 409 (1950). Deasy, C., *J. Amer. Leath. Chem. Assoc.*, **50**, 463 (1955). Green, G. H. (unpublished work).
[5] Takahashi, T., and Takei, M., *Bull. Jap. Soc. Sci. Fish.*, **20**, 421 (1954).
[6] Gustavson, K. H., *Nature*, **175**, 70 (1955); *Svensk. Kem. Tidskr.*, **67**, 116 (1955); *J. Amer. Leath. Chem. Assoc.*, **50**, 239 (1955).

Size and Shape of Cartilage Mucoprotein

The chondroitin sulphate – protein complex of cartilage was extracted from fresh homogenized bovine nasal septa by 30 per cent potassium chloride and precipitated with absolute alcohol after dialysis against running tap water and addition of potassium acetate; all operations were carried out at 2° C. The final product was analogous in chemical composition to the mucoprotein of Shatton and Schubert[1]. Solutions of the mucoprotein in phosphate buffer *M*/15, *p*H 7·0, were studied by viscometry, sedimentation, light scattering and flow birefringence.

The viscosimetric measurements were carried out at a velocity gradient $G = 0{\cdot}246$ sec.$^{-1}$ in a Couette apparatus; the intrinsic viscosity at 25° C. was $[\eta] = 207$ c.g.s. units. The sedimentation coefficient at infinite dilution and 20° C. was $s_0 = 6{\cdot}85 \times 10^{-13}$ c.g.s. units; the considerable spreading of the sedimenting boundary suggested a wide polydispersity of the mucoprotein. Determinations of light-scattering at $\lambda = 5460$ A. (the specific refractive index increment was $dn/dc = 0{\cdot}1680$ per gm./ml.) gave the following results: $M_w = 1{\cdot}98 \times 10^6$; $I_{45}/I_{135} = 2{\cdot}18$; $R_z = 1180$ A. (R_z being the Z-average radius of gyration); the anisotropy was negligible.

I have carried out the double extrapolation (to zero angle and zero concentration) of the Zimm plot obtained in the diagram $P^{-1}(\theta)$ vs. μ^2R^2 ($\mu = \frac{4\pi}{\lambda'} \sin \frac{\theta}{2}$, λ' being the wave-length of light in the solution, θ the angle between the incident and scattered beams) in order to compare the plot with the curves pertaining to spheres, coils and rods, respectively; it is known[2] that the curves relating to polydisperse systems fall below those of monodisperse systems (the latter are shown in Fig. 1).

As is evident from Fig. 1, the sphere model seems to be quite improbable; furthermore, it would require a hydrated specific volume (as deduced from R_z) of $V' = 4{,}450$ ml./gm., which appears to be much too high. A polydisperse system of rods, such as was suggested by Mathews and Lozaityte[3], though not incompatible with the light-scattering results, seems also highly improbable. The length of the rods (as deduced from R_z) would be about 4000 A.; such a system could scarcely fail to exhibit a strong flow birefringence, like, for example, tobacco mosaic virus

(this latter presents an intrinsic streaming birefringence $[\Delta n] = \lim_{\substack{G \to 0 \\ C \to 0}} \frac{\Delta n}{G\eta_0 C} = 5 \times 10^{-4}$); in the case of cartilage mucoprotein, on the contrary, the flow birefringence was negligible ($[\Delta n] \ll 10^{-6}$), a result which is in agreement with the negative results of Webber and Bayley[4] for an analogous product.

The hypothesis of a polydisperse system of coils seems to be the most satisfactory. My light-scattering results also indicate the absence, or at most a very small extent, of branching in the mucoprotein; indeed, Benoit[3] showed that branching increases the general upward curvature of curve 2, whereas my curve 4 exhibits a strong downward curvature. The possibility of a system of non-Gaussian coils, which could also explain such curvature[5], seems to be ruled out by the high value of the ratio L/r (L being the length of the filament and r the root-mean-square end-to-end distance of the coil).

On the assumption of such a polydisperse system of coils, I can, by the method of Sadron and Benoit[6], calculate the approximate value of M_n (strictly speaking, its upper limit); I have found $M_n = 480{,}000$; therefore, $M_w/M_n \geqslant 4$, a result which confirms the polydispersity observed in the sedimentation.

In order to check the mutual consistency of my experimental results as well as my conclusions, I applied the following equation proposed by Flory[7]:

$$\Phi^{1/3} P^{-1} = \frac{N s_0 [\eta]^{1/3} \eta_0}{M^{2/3} (1 - \bar{v}\rho)},$$ where $\Phi^{1/3} P^{-1}$ should be a universal constant independent of solvent, temperature and nature of polymer. Introducing in the above equation my values of $s_0 M_n [\eta]$ and assuming $\bar{v} = 0{\cdot}60$ ml./gm., I find $\Phi^{1/3} P^{-1} = 2{\cdot}1 \times 10^6$; the good agreement between this value and the theoretical one seems to confirm the consistency of the experimental results and the validity of the proposed model.

Giorgio Bernardi
Centre de Recherches sur les Macromolécules,
Strasbourg.
March 22.

[1] Shatton, J., and Schubert, M., *J. Biol. Chem.*, **211**, 565 (1954).
[2] Benoit, H., *J. Pol. Sci.*, **11**, 507 (1953).
[3] Mathews, M. B., and Lozaityte, I., *Fed. Proc.*, **15**, 1012 (1956).
[4] Webber, R. V., and Bayley, S. T., *Can. J. Biochem. Physiol.*, **34**, 993 (1956).
[5] Benoit, H., and Doty, P., *J. Phys. Chem.*, **57**, 958 (1953).
[6] Sadron, C., Benoit, H., and Daune, M., Int. Symp. Macromol. Chem., Milan–Turin (1954).
[7] Flory, P. J., "Principles of Polymer Chemistry" (Cornell Univ. Press, 1953).

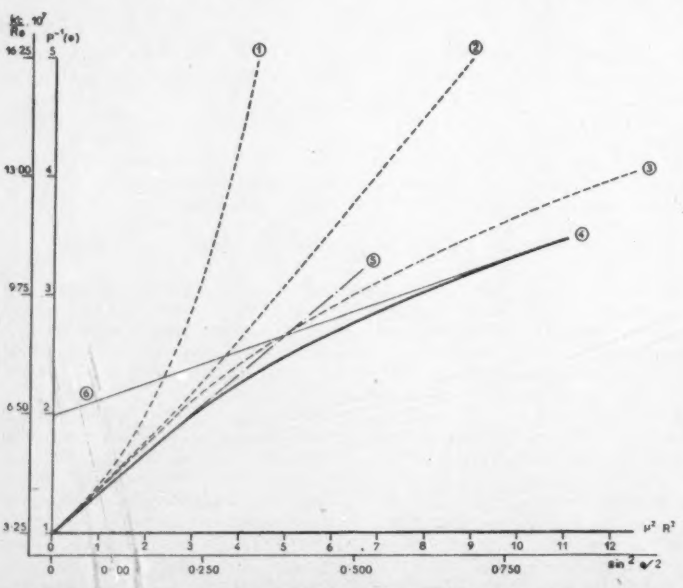


Fig. 1. Curves 1, 2 and 3 relate to monodisperse systems of spheres, coils and rods, respectively. Curve 4 is the Zimm plot extrapolation for $c = 0$, with its tangent at the origin (5) and the asymptote (6)

Ion Permeability of the Plasmalemma of the Plant Cell

It has recently been suggested by several workers[1] that the plasmalemma of the plant cell does not constitute a barrier to the diffusion of ions, and that there is a Donnan distribution of ions between the cytoplasm of the plant cell and the extracellular medium. As a corollary, it has been suggested[1c] that the electric resistance and capacity of plant tissue are to be attributed wholly to the properties of the tonoplast and bulk cytoplasm. However, it has been suggested that recent measurements of resistance and capacity on *Nitella* give the properties of the plasmalemma[2]; and a.c. measurements on *Chlorella*[3], which has no significant vacuole, appear to require a similar explanation. Results which I have obtained with cells of *Nitella* indicate that the plasmalemma of the *Nitella* cell acts as a barrier to the inward diffusion of calcium ions, and is responsible for the d.c. resistance of the cell bathed in a solution of potassium, sodium or calcium chloride. Thus if the cytoplasm contributes to the apparent free space for ionic diffusion, it cannot be in the simple way proposed for higher plant tissue[1]. Although one cannot argue from single cells of an alga to pieces of angiosperm tissue, it may be noted that there is evidence from *Nitella* that labelled ions do cross the plasmalemma much more rapidly than the tonoplast[4]; this situation is comparable with that in angiosperm tissue[1c].

Microelectrode experiments on *Nitella*[5] showed that the electric potential difference between cell sap and extracellular medium is located at the plasmalemma, the value being −160 mV. (interior negative) with the cells bathed in 0·1 m*M* potassium chloride solution. The location of the p.d. and its value were qualitatively in agreement either with the hypothesis of a Donnan distribution across a freely permeable plasmalemma, or with hypotheses involving a semi-permeable membrane. Further experiments by the same method (Walker, N. A., and Cooper, J., unpublished work) have, however, found a p.d. of −160 mV. across the plasmalemma of similar cells bathed in

their native pond water. Flame photometer analysis of this pond water gave the following (rounded-off) results:

$$[K^+]_o = 0{\cdot}03 \text{ m}M\text{ ; } [Na^+]_o = 0{\cdot}5 \text{ m}M\text{ ; } [Ca^{++}]_o = 0{\cdot}5 \text{ m}M$$

It will be sufficiently accurate if these concentrations are taken as equal to the activities. If now there is a Donnan distribution (or, more generally, if there is electrochemical equilibrium) across the plasmalemma for these ions, one can calculate their activities in bulk cytoplasm from the equation:

$$a_{cj} = a_{oj} \exp(-Z_jE/58)$$

where a_{cj} and a_{oj} are the activities of the jth ion in bulk cytoplasm and outside medium respectively, Z_j is the valence of the jth ion, and E is the electric p.d. between the two phases in millivolts. This calculation, for the cells in pond water, gives the following results:

$$a_{cK^+} = 18 \text{ m}M\text{ ; } a_{cNa^+} = 300 \text{ m}M\text{ ; } a_{cCa^{++}} = 180{,}000 \text{ m}M$$

The value for the calcium ion activity is absurd, so that this ion cannot be in electrochemical equilibrium across the plasmalemma. It is most improbable from energy considerations that this is due solely to the existence of a 'calcium pump', so that a degree of impermeability of the plasmalemma to calcium is very probably involved. The calculated values for potassium and sodium activities are not obviously impossible, and no conclusion is drawn from them. However, it seems from the time taken by labelled potassium and sodium to enter the cytoplasm[4] that the plasmalemma is also somewhat impermeable to these ions. This has been confirmed by the experiments reported below.

Microelectrodes have been inserted into the cell, as previously described[5], to measure the direct current resistances of the cell membranes in *Nitella*. A known direct current (generally 10^{-6} amp.) was passed across the protoplasm from one microelectrode with its tip in the vacuole to a salt bridge in contact with the bathing solution. A second inserted microelectrode enabled changes of p.d. due to the impressed current to be measured, either between the cytoplasm and the outside medium or between the cell sap and the outside medium. Ohm's law then gave the resistance from the measured change in p.d. and the current. As the indicating instrument was a galvanometer of 2-sec. period, transient p.d.'s due to the membrane capacity of the living cell[6] were not observed when the current was switched on or off. Reversing the direction of the current did not alter the measured resistance by more than 10 per cent. The measured value was corrected for the resistances of the bathing solution, the indifferent electrode and the potentiometer. These were the only resistances common to the current and potential circuits, apart from the resistance to be measured.

On seven occasions, in experiments on five cells, it was possible to measure the two required resistances within a short interval of time. The values in ohms $\times 10^3$ are:

Resistance vacuole to outside (R_{VO})	340	320	260	400	860	200	460
,, cytoplasm ,, (R_{CO})	330	310	260	300	710	190	360

Thus in every case the major part (75–100 per cent) of the d.c. resistance of the cell lay between the cytoplasm and the outside medium. These experiments were carried out with the cell in the following bathing solutions: 1·0 mM sodium chloride; 1·0 mM potassium chloride; 0·05 mM and 0·5 mM calcium chloride. The general conclusion is thus true of cells in these various solutions. (This variation in the composition of the bathing solutions, and variation in the sizes of the cells and their histories, account for much of the variation in the values quoted.) The resistance of the layer of cytoplasm 10μ thick is negligible compared with these values, whether one accepts the results of a direct measurement[7], or makes any plausible guess as to the free-ion concentration in cytoplasm. It therefore seems certain that the measured d.c. resistance (R_{CO}) is located at the plasmalemma, and so presumably is also the major part of the a.c. resistance[2]. Calculation indicates that the current distribution is reasonably uniform over the cell surface, so that the specific resistance of the membrane may be found from the product of the measured resistance and the area of the cell surface. A representative value so found for these experiments is 6,000 ohm sq. cm., which is lower than the d.c.[6] and a.c.[2] values previously reported, presumably due to differences in species and history of the cells.

It seems anomalous that the plasmalemma should have a higher electric resistance than the tonoplast, if it permits the more rapid salt penetration. Most of the ions crossing the plasmalemma in ion uptake or exchange must be unable to carry an electric current, that is, must be part of a neutral complex. This can occur if the membrane contains a lipid layer, as has often been suggested. Such a layer would contain few free ions to carry an electric current, but might contain sufficient carrier to provide high entry and exchange rates for ions. The carrier molecules would be required to cross the lipid layer always in an uncharged form. As a result, no direct relation would exist between the salt permeability and the electric resistance of the membrane. This model best explains observations on *Nitella* discussed here.

I thank Dr. J. N. Phillips, Mr. C. G. Greenham and Dr. B. I. H. Scott for helpful discussions and suggestions. This work will be fully reported elsewhere.

N. A. Walker

Division of Plant Industry,
Commonwealth Scientific and
Industrial Research Organization,
Canberra. March 1.

[1] (*a*) Vervelde, G. J., "Zoutophoping door Plantenwortels" (Veenman, Wageningen, 1952). (*b*) Butler, G. W., *Physiol. Plantarum*, **6**, 662 (1953). (*c*) Hope, A. B., and Robertson, R. N., *Aust. J. Sci.*, **15**, 197 (1953). (*d*) Hope, A. B., and Robertson, R. N., *Nature*, **177**, 43 (1956).

[2] Bennett, M. C., and Rideal, Sir Eric, *Proc. Roy. Soc.*, B, **142**, 483 (1954).

[3] Hope, A. B., *Austral. J. Biol. Sci.*, **9**, 53 (1956).

[4] Brooks, S. C., *J. Cell Comp. Physiol.*, **38**, 83 (1951).

[5] Walker, N. A. *Austral. J. Biol. Sci.*, **8**, 476 (1955).

[6] Blinks, L. R., *J. Gen. Physiol.*, **13**, 495 (1930).

[7] Gelfan, S., *Protoplasma*, **4**, 192 (1928).

Efficiency of Ion Transport in Biological Systems

The idea that active ion transport is linked directly to an electron-transferring respiratory system was first expressed clearly by Stiehler and Flexner[1] and has since been elaborated by other investigators[2,3]. On the basis of this hypothesis, the maximum value of the ratio (ion pairs transported/oxygen consumed) = 4 [4,5], since four electrons are transferred in the reduction of one molecule of oxygen to water. In support of

the theory, Robertson and Wilkins[5] showed experimentally with slices of carrot tissue that the ratio approached but did not exceed 4 as the concentration of salt in the medium was increased.

More recently, however, evidence has been accumulating that the ratio can exceed 4 in both animal and plant systems. Crane and Davies[6] claimed that (hydrochloric acid secreted/oxygen involved) in frog gastric mucosæ can be maintained at values exceeding 11 for considerable periods of time. Leaf and Renshaw[7] found with isolated frog skin that the number of sodium ions transported per oxygen molecule consumed ranged from 2 to 13, with a mean value of 6·82. On the assumption that only a part of the oxygen taken up by the tissue is involved in ion transport, 6·82 represents a minimum value, and the actual ratio may be as high as 18. Handley and Overstreet[8], studying the relation between respiration and salt absorption in excised barley roots, obtained values for (anions absorbed/oxygen involved) = 4·3–7·9 in potassium bromide solutions; 2·8–4·6 in sodium bromide solutions; and 0·3–18·7 in calcium bromide solutions. One of us (J. F. S.) obtained (anions absorbed/oxygen involved) > 4 with red beet root slices immersed in solutions of sodium chloride at low temperatures (3°–5° C.), although at 25° C. under otherwise similar conditions values of 2–3 were obtained.

It appears, therefore, that mechanisms of ion transport which depend on a direct linkage to electron transfer, such as the Lundegårdh hypothesis and the 'redox pump', must be rejected. An alternative hypothesis is that ion secretion and accumulation depend on the utilization of energy from phosphorylated compounds. On the assumptions that one high-energy phosphate bond ($\sim$ P) is utilized in the transport of only one ion pair, and that a net 38 ($\sim$ P) are produced from the complete oxidation of a mole of glucose, the maximum value for (ion pairs absorbed/oxygen involved) $\simeq 6 \cdot 3$. The average P/O ratio for the complete oxidation of pyruvate by isolated mitochondria[9] is 3, which would give a maximum P/O_2 or anions/oxygen ratio of 6. These considerations suggest that experimental anions/oxygen values close to 4 are approaching 60 per cent, rather than 100 per cent, of the theoretical maximum. If a finite number (>1) of ion pairs are transported per $\sim$ P the maximum value of (ion pairs absorbed/oxygen involved) will be a simple multiple of approximately 6. With plant tissues, the ratio is usually much lower than 6 (< 1 in wheat roots[10]), and this probably means that only a small fraction of the respiratory energy is utilized for accumulation. On the other hand, the fact that values of up to 18 have been obtained with both animal and plant materials suggests that at least three ion pairs may be transported per $\sim$ P under optimum conditions.

There are a variety of ways in which the energy stored in phosphorylated compounds could conceivably be utilized in ion transport. In general terms, phosphorylation may facilitate binding of the ion to its carrier, or it may be involved in the physical movement or in the subsequent breakdown of the ion-carrier complex. Some specific hypothetical mechanisms depending in various ways on the utilization of 'high-energy' phosphate compounds have been suggested[11–13] but at present these lack experimental proof.

It must be emphasized that the hypothesis linking ion transport to phosphorylation is not contradicted by any of the evidence assembled in support of the Lundegårdh or Conway hypotheses, since reduced respiratory intermediates and the cytochrome system are essential for the aerobic synthesis of adenosine triphosphate. The observation[14] that 2,4-dinitrophenol at certain concentrations stimulates electron transport and at the same time depresses salt absorption argues strongly against oxidation/reduction hypotheses, and favours a phosphorylation mechanism, since it is known that 2,4-dinitrophenol prevents adenosine triphosphate synthesis. Stimulation of respiration by added salts (the 'anion respiration' of Lundegårdh) can be explained if it is assumed that the adenosine diphosphate/adenosine triphosphate ratio in the cell controls the rate of oxidation. When energy (adenosine triphosphate) is utilized in the absorption of salt, it is probable that the increase in adenosine diphosphate concentration results in a stimulation of oxygen uptake[15].

Finally, a phosphorylation mechanism provides a unified hypothesis applicable to ion transport in anaerobic as well as aerobic systems, since phosphorylated compounds synthesized in fermentation may also supply energy for secretory processes.

J. F. Sutcliffe

Department of Botany,
King's College,
London.

D. P. Hackett

Department of Biology,
University of Buffalo,
Buffalo, New York.
May 17.

[1] Stiehler, R. D., and Flexner, L. B., *J. Biol. Chem.*, **126** 603 (1938).
[2] Lundegårdh, H., *Arkiv. Bot.*, **32**, A, 1 (1945).
[3] Conway, E. J., *Int. Rev. Cytol.*, **2**, 419 (1953).
[4] Lund, E. J., and Stapp, P., in "Bioelectric Fields and Growth", edit. by E. J. Lund, 235 (University of Texas Press, 1947.).
[5] Robertson, R. N., and Wilkins, M. J., *Nature*, **161**, 101 (1948).
[6] Crane, E. E., and Davies, R. E., *Biochem. J.*, **43**, 42 (1948); **49**, 169 (1951).
[7] Leaf, A., and Renshaw, A., *Biochem. J.*, **65**, 82 (1957).
[8] Handley, R., and Overstreet, R., *Plant Physiol.*, **30**, 418 (1955).
[9] Hunter, jun., F. E., in "Phosphorus Metabolism", edit. by McElroy, W. D., and Glass, B., **1**, 297 (Johns Hopkins Press, Baltimore, 1951).
[10] Lundegårdh, H., *Ann. Agric. Coll. Sweden*, **16**, 372 (1949).
[11] Goldacre, R. J., *Int. Rev. Cytol.*, **1**, 135 (1952).
[12] Steward, F. C., and Millar, F. K., Soc. Exp. Biol. Symposium, **8**, 367 (1954).
[13] Bennett, H. S., *J. Biophys. and Biochem. Cytol.*, **2** (Supp. 4), 99 (1956).
[14] Robertson, R. N., Wilkins, M. J. and Weeks, D. C., *Austral. J. Sci. Res.*, B, **4**, 248 (1951).
[15] Chance, B., and Williams, G. R., "Adv. in Enzymol.", **17**, 65 (1956).

Fungistasis as a Factor in the Rhizosphere Phenomenon

In the course of work in progress on soil inhibitory factors, it has been observed that the spores of certain fungi which are unable to germinate when introduced into fresh fertile soil on glass slides coated with 0·5 per cent peptone in 2·0 per cent agar, owing to the presence in the soil of a fungistatic factor, may germinate readily when seedling roots grow in their immediate vicinity, that is, within a distance of some 2 mm. This observation has been made with conidia of *Gliocladium roseum* and *Paecilomyces marquandii* on glass slides buried beneath germinating peas so that the seedling roots grew into contact with the slides; and also with *Fusarium solani* and two unidentified isolates of *Fusarium* in similar experiments using seedlings of pea, wheat and lettuce. *Fusarium*

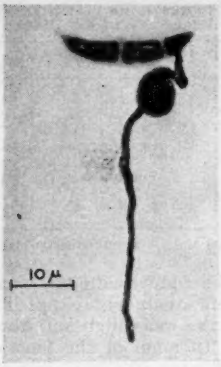


Fig. 1. Conidium of *Fusarium solani* that has produced a chlamydospore after being buried in soil. The latter has since germinated owing to the growth near it of a pea root

solani and one of the unidentified *Fusaria* show peculiar behaviour; in the presence of soil their conidia germinate normally, but usually produce terminal chlamydospores on short germ tubes and cease further development. Park[1] has reported similar formation of chlamydospores by *Fusarium roseum* in response to an inhibitory factor produced by *Bacillus macerans*. In the presence of seedling roots the chlamydospores germinate and growth is resumed (Fig. 1). According to the abstract of a thesis by Burke[2] on root rot of *Phaseolus vulgaris*, *Fusarium solani* f. *phaseoli* may exhibit the same type of behaviour in naturally infested root-rot soils. It has further been observed with *Gliocladium roseum* and with the *Fusaria* studied that the germ tubes show a strong tropic growth towards the roots, although those of *Paecilomyces marquandii* do not appear to show such directed growth.

While no definite explanation for the germination of previously inhibited fungal spores can yet be offered, it would seem likely that root excretions are involved. Rovira[3] has demonstrated the liberation of easily detectable quantities of sugars, including glucose, by the roots of pea and oat seedlings, and the previously reported effect of low concentrations of glucose in overcoming soil fungistasis[4] has been confirmed and extended to other sugars in the present work.

The rhizosphere effect is usually believed to be due primarily to the direct nutritional influence of substances liberated by roots and of sloughed-off root tissues. The indirect effect of root exudates in stimulating the germination of fungal spores which have been lying in the soil in a condition of environmental dormancy is likely to precede and to be of equal importance to any direct nutritional effect. The tropic growth of germ tubes towards the roots, added to the germination followed by vegetative growth and sporulation of spores on, and very close to, the roots, would contribute to the relative abundance of fungi in the rhizosphere and on the root surface as compared with soil away from the roots.

R. M. Jackson

Soil Microbiology Department,
Rothamsted Experimental Station,
Harpenden, Herts.

[1] Park, D., *Trans. Brit. Mycol. Soc.*, **39**, 239 (1956).
[2] Burke, D. W., *Diss. Abstr.*, **15**, 12, 2390 (1955).
[3] Rovira, A. D., *Plant and Soil*, **7**, 178 (1956).
[4] Dobbs, C. G., and Hinson, W. H., *Nature*, **172**, 197 (1953).

Ovicidal Action of Organo-phosphorus Insecticides

The response of insect eggs to organo-phosphorus insecticides presents anomalies for the hypothesis that these compounds exert their toxic effect by inhibition of the acetylcholinesterase of the nervous system. In the first place, the compounds are toxic to eggs treated before differentiation of the nervous system[1]. Secondly, eggs treated at an early state of development, before cholinesterase activity appears, continue to develop normally until just before hatching, and then die[2]. Since the ultimate toxic effect of anticholinesterases is thought to result from the abnormal concentration of acetylcholine, we have examined the acetylcholine content and cholinesterase activity during the embryonic development in normal and treated eggs of the housefly, *Musca domestica*. Our results show a striking coincidence between the appearance and rise in the acetylcholine content of *Musca* eggs and the lethal action of the organo-phosphorus insecticide parathion.

Musca eggs at 28° C. normally complete their embryonic development and hatch in twelve hours after oviposition. Large numbers of eggs were collected at timed intervals from 1 to 11 hr. after oviposition and assayed for acetylcholine using the frog's rectus abdominis muscle[3], and for cholinesterase activity by the standard manometric method (sodium bicarbonate, 0·025 *M*; acetylcholine, 0·01 *M*; temperature, 37° C.). Eggs were treated within one hour after oviposition by exposure on filter-papers treated with a 2 per cent acetone solution of parathion for a period of one hour. In conformity with Smith's observations[2] on peach tree borer eggs, we regularly observed that eggs treated in this way continued to develop normally until hatching, and then failed to emerge.

Table 1. Acetylcholine Content and Cholinesterase Activity of Normal and Parathion-treated Eggs of *Musca domestica*

Age of eggs (hr.)	Acetylcholine content (μgm./gm.)		Cholinesterase activity (μl. CO_2/125 mgm./hr.)	
	Untreated	Treated	Untreated	Treated
1–3–5	nil	nil	nil	nil
7	nil	nil	14·9	—
9	5	7	18·8	—
11	490	742	26·5	Complete inhibition

Table 1 shows that neither acetylcholine nor cholinesterase activity could be detected during the first five hours of development. At seven hours, cholinesterase activity appeared in untreated eggs and increased up to the time of emergence. Acetylcholine was first detected in untreated eggs at nine hours and then increased to nearly 500 μgm./gm. during the next two hours. This extraordinary increase in the acetylcholine contents of developing *Musca* eggs was verified in four separate experiments, and gives credence to the high values reported by Yushima and Chino[4] for the acetylcholine content of certain insect eggs. We confirmed that the substance assayed on the rectus abdominis muscle of frog was in fact acetylcholine by (*a*) its reaction with hydroxylamine-ferric chloride[5] and (*b*) by paper chromatography[6]. Eggs treated with parathion showed the same time-course of appearance and rise in acetylcholine, but the values obtained were about 50 per cent higher than in untreated eggs. This increase in acetylcholine content after treatment with anti-

cholinesterases has also been demonstrated in adult houseflies[7]. The cholinesterase activity of the treated eggs was completely inhibited.

These findings seem to resolve the anomaly of the delayed action of anticholinesterases on insect eggs. If the ultimate toxic agent in anticholinesterase poisoning is acetylcholine, then no mortality would be expected during early embryonic development before this substance is present. However, late in development and coincidental with the time of hatching, high concentrations of this substance are present. If, at this time, the normal controlling mechanism, cholinesterase, is inhibited, the embryo is exposed to these high concentrations of acetylcholine and death ensues.

K. N. Mehrotra

Department of Zoology,
University of Western Ontario,
London, Ontario.

B. N. Smallman

Canada Department of Agriculture,
Science Service Laboratory,
London, Ontario.

[1] Lord, K. A., and Potter, C., *Ann. App. Biol.*, **38**, 495 (1951).
[2] Smith, E. H., and Wagenknecht, A. C., *J. Econ. Ent.*, **49**, 777 (1956).
[3] Feldberg, W., "Methods in Medical Research", **3** (Chicago Year Book, 1950).
[4] Yushima, T., and Chino, H., *Annot. Zool. Jap.*, **26**, 228 (1953).
[5] Hestrin, S., *J. Biol. Chem.*, **180**, 249 (1949).
[6] Chefurka, W., and Smallman, B. N., *Canad. J. Biochem. and Physiol.*, **34**, 731 (1956).
[7] Smallman, B. N., and Fisher, R. W., Proc. Tenth Int. Cong. Ent. (1956) (in the press).

Hens with Bilateral Oviducts

As the reproductive organs of the female chicken develop there is an atrophy of the right gonad and the right oviduct which begins during early embryogeny. Persistency of these structures on the left side results in only one functional ovary and oviduct. A suspicion that bilateral oviducts were present in an inbred strain of Rhode Island Reds resulted when hens were being artificially inseminated. As each hen was prepared for receiving semen, manual pressure was exerted so that the vagina would be extruded. When this practice was followed with line *SD*-11 hens (from the Rhode Island Red inbred line) it was frequently observed that apparently two vaginas were appearing at the cloaca. Subsequent autopsies have verified that at least a portion of the right oviduct has persisted in some of the *SD*-11 hens.

Between August 15 and November 1, 1956, nine mature *SD*-11 hens were autopsied. Six of the hens had abnormal reproductive structures on the right side. The rudimentary right oviducts were, in all instances, attached to the cloaca in a manner similar to that of the normal left oviducts. The measured lengths (see Table 1) indicate that in four of the six cases the rudiment was approximately half the length of the normal duct. Gross examination revealed that the following areas of the right oviduct had not been subjected to normal avian degeneration during development: vagina, uterus, isthmus and part of the magnum. The two shorter rudiments each had a cystic mass appended distally. The thin-walled mass of female 322*D* was approximately 12 mm. × 8 mm. and that of female 5741*E* was approximately 28 mm. in diameter. Macroscopically

Table 1. Oviduct Lengths (in mm.) for Nine Non-Laying Mature Rhode Island Red Hens

Hen No.	Left oviduct	Right oviduct
322*D*	100	25
366*D*	110	60
377*D*	125	60
1703*E*	110	*
3088*E*	100	65
4583*E*	110	55
4677*E*	110	*
4685*E*	110	*
5741*E*	100	30

* Normal, unilateral reproductive structures.

the tissue of the right oviducts appeared similar to that of the left oviducts, except for one female. In 3088*E* the tube was tough and fibrous, suggestive of a fibroma. In none of the females was a right ovary observed.

Persistency of the right oviduct in chickens, or of its rudiments, has been reported in isolated cases[1]. Although Wodzicki[2] has reported that the right oviduct tends to persist in ducks, there appears to be no report in the literature indicating that the persistency of the right oviduct is inherited in chickens. Development of the right ovary in hawks and falcons[3] has apparently little or no relation to growth of the right oviduct[4]. Thus, although rare instances of dual persistency have been reported[5], it is not unusual to observe that the normally absent oviduct can persist without the corresponding ovary. Because of their separate embryonic primordial origin, this would be expected.

Line *SD*-11 has, for eleven years, been developed under a designed inbreeding programme. The present coefficient of inbreeding is 70 per cent < 78 per cent. No unrelated stock has been introduced during this period of time and no selection has been made for bilateral oviducts. The relatively high incidence observed in the few birds that have been autopsied indicates that the persistency is influenced by genotype. This suggests, for the first time, that persistency of the right oviduct may be controlled genetically in chickens.

Walter Morgan
William Kohlmeyer

Department of Poultry Husbandry,
South Dakota State College,
Brookings.
Feb. 25.

[1] Champion, L. R., *Poultry Sci.*, **34**, 184 (1955). Crew, F. A. E., *J. Anat.*, **66**, 100 (1931). Quinn, J. P., *et al.*, *Poultry Sci.*, **18**, 381 (1939).
[2] Wodzicki, K., *Bull. Acad. Polon. Sci. Letters*, **2**, 385 (1934).
[3] Gunn, T. E., *Proc. Zool. Soc. Lond.*, 63 (1912)
[4] Stanley, A. J., and Witschi, E., *Anat. Rec.*, **76**, 329 (1940).
[5] Bryant, R. L., *Poultry Sci.*, **23**, 77 (1944).

Parasitism in Relation to the Pituitary of *Ophicephalus punctatus* and *Barbus stigma*

The interrelationship between the pituitary and the target organs is, more or less, well known. According to Kerr[1], the occurrence of the plerocercoid stage of a tapeworm (*Ligula intestinalis*) in the body cavity of the roach *Leuciscus rutilus* (Flem.) results in a marked regression of the gonads and in the reduction of the basophils in the middle glandular portion of the pituitary. In the case of the stickleback (*Gasterosteus aculeatus* L.), however, infected with *Schistocephalus solidus*, no difference between

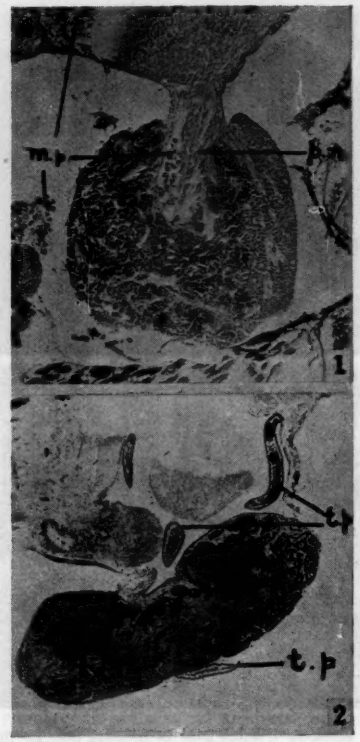


Fig. 1. Median sagittal section of the pituitary of *Barbus stigma* showing the presence of myxosporidian parasite in the pars nervosa. *m.p.*, myxosporidian parasite; *p.n.*, pars nervosa. (× 80)

Fig. 2. Median sagittal section of the pituitary of *Ophicephalus punctatus* showing the occurrence of trematode parasite in the neighbourhood of the pituitary. *t.p.*, trematode parasite. (× 64)

the normal and the parasitized fish could be detected and the influence of *Schistocephalus solidus* on *G. aculeatus* is less manifest. The functional relationship between the pituitary and the gonads in fishes has been determined by the injection of pituitary extracts[2] or by hypophysectomy[3]. Recent studies on the correlation of the cyclical changes in the pituitary and in the gonad of *Cyprinus carpio*[4], *Carassius auratus*[4] and *Rhodeus amarus*[5] also lend support to the existence of the stipulated relationship.

In *Ophicephalus punctatus* (Bloch), I have observed the presence of a trematode parasite in close proximity to the pituitary. These parasites occur in the third ventricle, in the infundibular recess and even on the surface of the pituitary (Fig. 2). The specimen that is being reported upon had regressed testis with residuary sperms in the seminal tubules. The histological structure of the pituitary does not show any abnormality.

Also, the pituitaries of two specimens of *Barbus stigma* (Cuv. Val.) were found to be infested with myxosporidian parasite. In one case, the gonad was mature and ready for spawning. The parasites abounded in the infundibular recess and on the meninges covering the pituitary. In the other case, these parasites were present inside the pars nervosa of the pituitary (Fig. 1) or occurred in the form of cysts on the gonad. Comparison of the pituitary and the gonad of the parasitized specimen with those of the non-parasitized one of approximately the same size and condition did not show any noticeable difference. This suggests that the reported parasitization of *B. stigma* and *O. punctatus* was not such as to impair the function of the basophils of the ubergangsteil.

In the present cases, the parasites occur in close proximity to the pituitary or lie within it, but neither the internal structure of the gonad nor the number of the basophils is affected thereby. The condition found in *O. punctatus* and *B. stigma* is, therefore, milder than that reported of *G. aculeatus* by Kerr[1].

A. G. Sathyanesan

Zoology Department,
Banaras Hindu University,
Varanasi 5.
March 20.

[1] Kerr, T., *Quart. J. Micr. Sci.*, **89**, 129 (1948).
[2] Cardoso, D. M., *C.R. Soc. Biol.*, **115**, 1347 (1934). Houssay, B. A., *ibid.*, **106**, 377 (1931).
[3] Matthews, S. A., *Biol. Bull.*, **76**, 241 (1939).
[4] Scruggs, W. M., *J. Morph.*, **88**, 441 (1951).
[5] Bretschneider, L. H., and Duyvene de Wit, J. J., "Sexual Endocrinology of Non-mammalian Vertebrates" (Amsterdam, 1947).

Classification of Wool Follicles in Sheep

A RECENT communication by Lyne[1] notes the presence in some adult merino sheep and one Corriedale ewe of "bundles of primary follicles" having a common neck. Lyne points out that these follicles would normally be classed as secondary follicles in counts to determine the ratio *S/P* and that therefore "some of the published observations on the numbers and ratios of follicle types must be re-interpreted".

It is certainly important that care should be exercised in identifying follicles as either primary or secondary during counts made to determine the ratio *S/P*; but perhaps as one of the authors of the early classification of follicles in sheep[2], I may be permitted to question the necessity, at present, of re-interpreting published ratios of follicle types. The division of follicles into secondary and primary, although arbitrary, is extremely useful and the basic value to fleece studies of the ratio *S/P* rests largely on the assumption that secondary follicles are initiated and differentiated in a growth phase of the coat which is later than that in which primaries are differentiated: the distinction based on this assumption is, in the majority of instances, justified by evidence from coat-development studies. Experience in follicle-population studies has shown that when observing and counting follicles, particularly in adult skin and in merino skin with its high density of follicles, the classification of some follicles is difficult, and in these laboratories such follicles are classed separately as of 'doubtful identity'. Caution, as Lyne implies, is therefore necessary in classifying follicles, and I agree fully with him and with Carter[3] in this.

It would seem then that the significance to *S/P* determinations of Lyne's useful and interesting observation cannot be established until there is further evidence to show whether follicles of the type he observed can in fact be justifiably classed as either primary or secondary. These follicles may not even have developed by branching as Lyne assumes; as shown in his figure, they are smaller than the large, obvious primary depicted, have no sweat glands and may have been differentiated much later than the original primaries; if this is so, the fact that these

and the original primary lead into a common neck loses its significance in assigning the smaller follicles to one category or another and they may have all the characteristics of secondary follicles. To assess their significance in population studies, further observations on the differentiation of these follicles would be welcome.

A. B. Wildman
Wool Industries Research Association,
Leeds.
May 8.

[1] Lyne, A. G., *Nature*, **179**, 825 (1957).
[2] Wildman, A. B., and Carter, H. B., *Nature*, **144**, 783 (1939).
[3] Carter, H. B., *Animal Breeding Abstracts*, **23**, No. 2, 101 (1955).

Vernal Sloughing of Sludge Deposits in a Sewage Effluent Channel

Vernal sloughs in polluted streams, associated with the break-up of *Sphaerotilus* growths and *Carchesium* colonies, have been recorded by Hawkes[1]. These growths collect silt and humus and, on becoming detached from the stream bed, release large amounts of organic material into suspension.

In April 1954, masses of chironomid tubes were observed floating in the effluent channel of a sewage works using the activated sludge process. The tubes were composed of sludge which had settled on the bed of the channel and the tube-masses were several inches in diameter. This vernal sloughing of the channel bed was associated with the first spring emergence of *Chironomus riparius*, Meigen. The larvæ of this midge were present in densities exceeding 100,000/m.[2] in the winter, spring and early summer of 1954.

Recently, when the effluent temperature was approximately 10° C., sludge was collected containing large numbers of larvæ and placed in a glass tank at approximately 20° C. After a few days the surface layer, the upper zone of which was composed of chironomid tubes, broke away from the deeper layers (Fig. 1), the surface layer being buoyed up by entrapped gas bubbles. Fig. 2 shows conditions after emergence of the midges, the tube layer having separated completely from the rest of the deposit. An analysis was made of the gas evolved by the sludge (Table 1). Its composition is similar to that produced by a group of Thames Estuary muds investigated by Grindley[3], with more than 70 per cent methane.

The large quantity of gas produced at the higher temperatures[2,3] is prevented from escaping by the thick layer of chironomid tubes, and the accumulation of bubbles underneath and within these tubes eventually causes the layer to break off in large masses. High densities of larvæ are necessary for the formation of the tube layer, and its instability, as the upper zone of the deposit, seems to be increased by the emergence of the midges. It is possible that the irrigation currents produced by the larvæ facilitate

Table 1. Analysis of Gas evolved by Sludge

Gas	Volume (per cent)
Carbon dioxide	7·4
Methane	74·7
Oxygen	0·2
Hydrogen sulphide	0
Hydrogen	0
Nitrogen	17·7

Fig. 1. Break-up of sludge deposits resulting from gas formation

Fig. 2. Separation of the tube-layer after a midge emergence

to some extent the removal of gas bubbles from the tube-layer matrix. The slough is particularly associated with the first spring emergence, when water temperatures are rising and when the tube-layer produced by over-wintering larvæ is especially well developed. This tube-layer incorporates much of the solid matter which settles during the winter period.

Thermograph records of the effluent kept from April 1954 until August 1955 indicated that the temperature was rarely higher than 20° C. in the summer or lower than 10° C. in the winter. In April 1954 the effluent temperature varied between 13° and 16° C.

The release of large quantities of organic matter from the benthos is likely to lower the dissolved oxygen concentration in the water and may produce conditions adverse to fish. Furthermore, the superficial resemblance of these tube masses to untreated sewage solids may give rise to complaints from riparian owners.

I should be glad to receive any further observations concerning this vernal sloughing associated with the emergence of midges.

R. W. Edwards

Freshwater Biological Association
Pollution Research Unit,
Water Pollution Research Laboratory,
Department of Scientific and Industrial Research,
Stevenage, Herts.

[1] Hawkes, H. A., paper presented to the Inst. Sew. Purif. (Jan. 1957).
[2] Grindley, J., *Dock Harb. Author.*, **36**, 79 (1955).
[3] Rudolfs, W., *Indust. Eng. Chem.*, **30**, 337 (1938).

FORTHCOMING EVENT

Thursday, July 18

LINNEAN SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 11.30 a.m.—Symposium on "Biochemistry and Taxonomy". Speakers include Dr. E. C. Bate-Smith, Dr. C. R. Metcalfe, Dr. J. M. Rowson, Prof. Darnley Gibbs, Dr. P. R. Enslin, Prof. R. Hegnauer, Dr. R. Hill and Dr. J. G. Hawkes.

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ASSISTANT BIOCHEMIST, Basic Grade (with a science degree preferably with honours in biochemistry or chemistry, or the A.R.I.C.)—The House Governor, The General Hospital, Steelhouse Lane, Birmingham 4 (July 20).

ASSISTANT CHEMISTS (with a degree in chemistry or agricultural chemistry or A.R.I.C.), for analytical work on crops and soils (Ref. A); CHEMISTS or HORTICULTURALISTS (with a degree in horticulture or chemistry), to take charge of glasshouse work on soils and crop nutrition and to assist with analysis of crops grown (Ref. B); and an ASSISTANT MYCOLOGIST (preferably with a degree in botany or agricultural botany), for work on cereal diseases (Ref. C)—The Secretary, Rothamsted Experimental Station, Harpenden, Herts, quoting appropriate Ref. (July 20).

ASSISTANTS (2), Grade B, IN THE MATHEMATICS DEPARTMENT, to teach Mathematics (Pure and Applied) to the level of the higher national certificate and B.Sc. General Degree, Part I—The Principal, Derby and District College of Technology, Normanton Road, Derby (July 20).

CHIEF LABORATORY STEWARD (with suitable previous laboratory experience and familiar with the usual laboratory arts)—The Principal, Derby and District College of Technology, Normanton Road, Derby (July 20).

PHYSICIST (Basic Grade), for work initially on problems associated with radium and X-ray therapy and diagnosis and later with radioactive isotopes; and a PHYSICIST (Basic Grade) for work initially on problems associated with radioactive isotopes and later with radium and X-ray therapy and diagnosis—The Secretary, Hammersmith Hospital and Postgraduate Medical School, Du Cane Road, London, W.12 (July 20).

READER (with high academic and professional qualifications and considerable research experience) IN CHEMICAL ENGINEERING—The Registrar, College of Technology, Birmingham 1 (July 20).

SENIOR PHYSICIST FOR DUTIES IN THE RADIOTHERAPY DEPARTMENT—The Secretary, North Middlesex Hospital, London, N.18 (July 22).

LECTURER (with a degree in agricultural science and appropriate postgraduate experience, and preferably lecturing experience) IN AGRICULTURAL BIOLOGY—The Secretary to the Governing Body, Egerton Agricultural College, P.O. Njoro, Kenya (July 27).

STATISTICIAN (with an honours degree in mathematics, either including statistics or with a postgraduate diploma in statistics, and preferably experience in applying statistics to biological problems), for the design and analysis of experiments—The Secretary, National Vegetable Research Station, Wellesbourne, Warwick (July 27).

SECRETARY and ASSISTANT DIRECTOR (preferably with a university degree in a branch of natural history, or archæology, or the Diploma of the Museums Association)—The Secretary, The Manx Museum, Douglas, Isle of Man (July 29).

ASSISTANT IN GEOLOGY—The Secretary of University Court, The University, Glasgow (July 30).

LECTURER or ASSISTANT LECTURER IN ZOOLOGY at the University of Otago, Dunedin, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, July 31).

LECTURER (with experience in economic geography, cartography, surveying, and the conduct of laboratory and field classes) IN GEOGRAPHY at the University of Cape Town, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa, July 31).

LECTURERS (2) (with practical experience in the design of electrical plant, automatic control or electronics) IN ELECTRICAL ENGINEERING—The Registrar, Queen Mary College (University of London), Mile End Road, London, E.1 (July 31).

READER IN PHARMACOLOGY IN THE DEPARTMENT OF HUMAN PHYSIOLOGY AND PHARMACOLOGY, University of Adelaide, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, July 31).

SENIOR TECHNICIAN IN ZOOLOGY at University College, Ibadan, Nigeria—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (July 31).

SENIOR RESEARCH WORKERS (2) (with considerable research experience) AT THE AGRICULTURAL RESEARCH COUNCIL'S POULTRY RESEARCH CENTRE, Edinburgh, to investigate problems concerning growth and reproduction in the domestic fowl with reference to the importance of endocrine mechanisms—The Secretary, Agricultural Research Council, Cunard Building, 15 Regent Street, London, S.W.1 (August 12).

ASSISTANT IN THE DEPARTMENT OF ZOOLOGY in St. Salvator's College—Joint Clerk to the University Court, College Gate, St. Andrews (August 15).

ASSISTANT PROFESSORS (2) (preferably with the Ph.D. degree in mathematics) IN THE DEPARTMENT OF MATHEMATICS, University of Western Ontario, Canada—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Canada, August 15).

CHAIR OF CHEMICAL PATHOLOGY in the University of Cape Town—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa, August 15).

LECTURER IN SOIL SCIENCE; a LECTURER IN CHEMISTRY; and a SENIOR LECTURER or LECTURER IN MATHEMATICS at the University of Ghana—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (August 20).

READER IN ELECTRICAL ENGINEERING at Queen Mary College—The Academic Registrar, University of London, Senate House, London, W.C.1 (August 22).

READER (highly qualified in the physiological or nutritional aspects of lactation) IN DAIRY HUSBANDRY at the University of Sydney, Australia, to develop a research and teaching unit on the University Animal Husbandry Farms near Camden, New South Wales—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, August 24).

LECTURER (preferably with qualifications in one of the following: (*a*) first-year teaching in botany; (*b*) algology, especially marine algology; or (*c*) cytology or cytogenetics) IN THE DEPARTMENT OF BOTANY, University of Cape Town—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa, August 31).

LECTURER (preferably with qualifications in the ecology of vertebrates) IN NATURAL HISTORY (ANIMAL ECOLOGY)—The Secretary, The University, Aberdeen (August 31).

PROFESSOR AND HEAD OF THE DEPARTMENT OF AIRCRAFT PROPULSION—The Principal, The College of Aeronautics, Cranfield, Bletchley, Bucks (August 31).

SESSIONAL INSTRUCTORS IN CHEMISTRY—The Chairman, Department of Chemistry, University of Alberta, Edmonton, Alberta, Canada (August 31).

SOIL SURVEYOR (male, with a first- or second-class honours degree (science)) IN THE DEPARTMENT OF PEDOLOGY, Soil Survey (Scotland) Section—The Secretary, Macaulay Institute for Soil Research, Craigiebuckler, Aberdeen (August 31).

CHAIR OF PHYSICS in the University of Khartoum—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (September 30).

LECTURER IN THEORETICAL PHYSICS—The Registrar (Room 9 O.R.B.), The University, Reading (September 30).

PROFESSOR OF APPLIED MATHEMATICS—The Registrar, University Office, 46 North Bailey, Durham (September 30).

SENIOR LECTURER IN GEOCHEMISTRY IN THE DEPARTMENT OF MINERALOGY AND GEOLOGY, University of Cape Town—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa, September 30).

LECTURER (preferably with a medical qualification and qualified to teach for the Honours School of Physiology) IN MEDICINE—The Very Reverend the Dean, Christ Church, Oxford (October 26).

AGRONOMIST (with a university degree in agriculture, and experience in field experimentation, preferably with tropical crops) IN THE DEPARTMENT OF AGRICULTURE, British Guiana, to initiate and carry out crop and fertilizer trials where soil surveys are being carried out to determine optimum land use—The Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, quoting BCD. 79/30/01.

ASSISTANT BIOCHEMIST IN THE DEPARTMENT OF PATHOLOGY—The Secretary, Salford Royal Hospital, Chapel Street, Salford 3, Lancs.

ASSISTANT, Grade B (with a good honours degree) IN MATHEMATICS—The Clerk to the Governors, South-East Essex Technical College, Longbridge Road, Dagenham.

ASSISTANT LECTURER IN MATHEMATICS—The Secretary, Royal College of Science and Technology, Glasgow.

ASSISTANT or ASSOCIATE PROFESSOR TO TEACH INORGANIC CHEMISTRY IN FRENCH at the undergraduate and graduate levels—The Director of the Chemistry Department, Laval University, Quebec, Que., Canada.

ASSISTANT WARDEN (with a degree in zoology and an interest in ornithology and freshwater biology) at Flatford Mill Field Centre, East Bergholt, near Colchester, Essex—The Secretary and Treasurer, Field Studies Council, Balfour House, 119–125 Finsbury Pavement, London, E.C.2.

BIOCHEMISTS (preferably female, with a good honours degree, and at least two years postgraduate experience of biochemical work) at the Medical Research Council's Infantile Malnutrition Research Unit, Mulago Hospital, Kampala, Uganda—The Personnel Officer, Medical Research Council, 38 Old Queen Street, Westminster, London, S.W.1.

DEMONSTRATOR (with an honours degree in chemistry or biochemistry and prepared to engage in research in biochemistry with a view to obtaining a higher degree) IN THE DEPARTMENT OF CHEMISTRY AND BIOCHEMISTRY—The Dean, St. Thomas's Hospital Medical School, London, S.E.1.

MEDICAL LABORATORY TECHNOLOGIST (A.I.M.L.T., and wide experience of medical laboratory technique, including bacteriology and biochemistry) in the Nigerian Federal Government Medical Department—The Crown Agents, 4 Millbank, London, S.W.1, quoting M.3/43647/NF.

RESEARCH ASSISTANT (with H.N.C. or equivalent qualification and capable of constructing experimental apparatus, and preferably some experience in chemical analysis) IN THE PHYSICAL CHEMISTRY LABORATORY of the Chemistry Department of the Association in London, to take active part in laboratory research work on the physico-chemical studies of ferrous metallurgical processes—The Personnel Officer, British Iron and Steel Research Association, 11 Park Lane, London, W.1, quoting "C.P.7".

SENIOR LECTURER (preferably with a higher degree in chemical engineering, and with teaching experience) IN CHEMICAL ENGINEERING at University College, Mandalay, Burma—The Ministry of Labour and National Service (E.9), 26–28 King Street, London, S.W.1, quoting A.12/BUR/TCS/217.

STATISTICIAN (with a good honours degree in mathematics or statistics) IN THE SECTION OF STATISTICS, for biometrical research and consultation—The Secretary, National Institute for Research in Dairying, Shinfield, Reading, quoting Ref. 57/9.

TECHNICAL INFORMATION OFFICER (preferably with a degree or similar qualification and experience in engineering or physics (especially electronics), and/or experience of information work, or at least G.C.E. (A) or equivalent) IN THE LIBRARY at the A.E.R.E., Harwell, for

duties which include abstracting and indexing technical reports, answering inquiries, literature searching, and the preparation of bibliographies—The Group Recruitment Officer, Atomic Energy Research Establishment, Harwell, Didcot, Berks, quoting Ref. 826/34.

Technician (with general laboratory experience)—Nuffield Professor of Surgery, Nuffield Department of Surgery, Radcliffe Infirmary, Oxford.

Training Manager (with first-hand experience in training young people), to supervise the training of junior scientific staff in research laboratory techniques in chemistry, physics and metallurgy, and to advise on courses of study at local technical colleges—The Group Recruitment Officer (808/34), Atomic Energy Research Establishment, Harwell, Didcot, Berks.

Veterinary Laboratory Technologists (A.I.M.L.T., or holding a technical qualification in chemistry or biochemistry, and with experience of general pathology and bacteriology techniques) in the Nigerian Federal Government Department of Veterinary Research—The Crown Agents, 4 Millbank, London, S.W.1, quoting M.3/44208/NF.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Institution of Gas Engineers. Publication No. 501: Presidential Address (94th Annual General Meeting). Pp. 15. Publication No. 502: First Dempster Travelling Fellowship Report (Abridged). Aspects of the Long-Distance Transmission of Gas. By J. F. Day. Pp. 25. Publication No. 503: Pressure Gasification of Brown Coal at Morwell, Australia. By Dr. R. S. Andrews. Pp. 31. Publication No. 504: Coal Supplies for the Gas Industry. By Charles Johnson. Pp. 21. Publication No. 505: The Development of Catering Appliances. By E. W. B. Dunning. Pp. 42. Publication No. 506: An Approach to the Use of Oil Gas in an Integrated System. By L. P. Ingram. Pp. 34. Publication No. 507: Meeting the Gas Load in the North West. By W. Hodkinson and F. Litler. Pp. 28. Publication No. 508: Gas Industry Finance. By Wilfrid Bailey. Pp. 30. Publication No. 509: The Application of Work Study in the West Midlands Gas Board. By H. B. Bassett and W. J. F. Bryce. Pp. 35. (London: Institution of Gas Engineers, 1957.) [225

Titration in Non-Aqueous Solvents. By A. H. Beckett and E. H. Tinley. Second edition. Pp. iv+43. (Poole: British Drug Houses, Ltd., 1957.) [305

City of Liverpool. Centenary of the Brown Library and its Satellites, 1857–1957. Pp. 24. (Liverpool: Central Public Libraries, 1957.) [305

Guide to I.G.Y.: International Geophysical Year, 1957–8. Foreword by Sir James Wordie, and contributions by Members of the British Committee. Pp. 48. (London: Methuen and Co., Ltd., 1957.) 2s. 6d. [305

Report of the Royal Commission on the Law Relating to Mental Illness and Mental Deficiency, 1954–57. Pp. x+306. (Cmnd. 169.) (London: H.M. Stationery Office, 1957.) 10s. 6d. [305

This is T.I. Today. Pp. 12. (London: Tube Investments, Limited, 1957.) [305

British Museum (Natural History). The Culicine Mosquitoes of the Indomalayan Area. Part 1: Genus *Ficalbia* Theobald. By P. F. Mattingly. Pp. 61. 18s. The John Murray Expedition, 1933–34. Scientific Reports. Vol. 10, No. 4: The Sessile Tunicata. By Patricia Kott. Pp. 129–150. 8s. (London: British Museum (Natural History), 1957.) [305

Cyprus: a Review of Events in 1956. Pp. 8. (London: Cyprus Government (London Office), 1957.) [305

Enosis and Its Background. (An article reprinted from *The Round Table*, March 1957, No. 186.) Pp. 12. (London: The Round Table, Ltd., 1957.) [305

Philosophical Transactions of the Royal Society of London. Series A: Mathematical and Physical Sciences. No. 971, Vol. 249 (30 May 1957): The Asymptotic Solution of Linear Second Order Differential Equations in a Domain Containing a Turning Point and a Regular Singularity. By R. C. Thorne. The Asymptotic Expansion of Legendre Functions of Large Degree and Order. By R. C. Thorne. Pp. 585–621. 11s. 6d. Series B: Biological Sciences. No. 676, Vol. 241 (23 May 1957): Interglacial Deposits at Bobbitshole, Ipswich. By R. G. West. The Non-Marine Mollusca of the Interglacial Deposits at Bobbitshole, Ipswich. By B. W. Sparks. Pp. 44+4 plates. 20s. (London: Royal Society, 1957.) [305

Royal Institute of Chemistry. Report of the 79th Annual General Meeting. Pp. 24. (London: Royal Institute of Chemistry, 1957.) [305

Building Research Station Digest, No. 97 (April, 1957): Questions and Answers. Pp. 4. (London: H.M. Stationery Office, 1957.) [305

Oundle School Natural History Society. Annual Report, 1956. Pp. ii+38. (Oundle, Peterborough: Oundle School Natural History Society, 1957.) [305

Nationalism, Colonialism and Neutralism. By Sir Ivor Jennings. (Fifteenth Montague Burton Lecture on International Relations, delivered at the University, Leeds, on Tuesday, 19th February, 1957.) Pp. 12. (Leeds: The University, 1957.) 6d. [305

Ministry of Agriculture, Fisheries and Food. Fishery Investigations. Series 2, Vol. 21, No. 1: Oyster Production in the Rivers Crouch and Roach, Essex, from 1950 to 1954. By G. Duncan Waugh. Pp. iii+47. (London: H.M. Stationery Office, 1957.) 10s. 6d. net. [305

Other Countries

United States Department of Agriculture. Production Research Report No. 1: Soil and Crop Studies at the Big Spring, Texas, Field Station. By F. E. Keating and O. R. Mathews. Pp. 31. (Washington, D.C.: Government Printing Office, 1957.) 30 cents. [225

Pacific Science, Vol. 11, No. 2 (April, 1957). (A quarterly devoted to the Biological and Physical Sciences of the Pacific Region.) Pp. ii+141–252. Subscription price: 3 dollars a year; Single copies, 1 dollar. (Honolulu: University of Hawaii Press, 1957.) [225

Indian Council of Agricultural Research. Scientific Monograph No. 20: Classification of Citrus Fruits of Assam. By S. C. Bhattacharya and S. Dutta. Pp. vi+110+84 plates. (Delhi: Manager of Publications, 1956.) Rs. 34; 52s. [225

Colony of Mauritius. Meteorological Observations and Climatological Summaries. January, 1955. Pp. ii+12. February, 1955. Pp. 12. March, 1955. Pp. 12. April, 1955. Pp. 12. May, 1955. Pp. 12. June, 1955. Pp. 12. (Port Louis: Government Printer, 1956 and 1957.) [305

Fondation Universitaire. Trente Sixième Rapport Annuel, 1955–1956. Pp. 131. (Bruxelles: Fondation Universitaire, 1957.) [305

World Health Organization. Technical Report Series No. 117: Study Group on Atherosclerosis and Ischaemic Heart Disease—Report. Pp. 40. (Geneva: World Health Organization; London: H.M. Stationery Office, 1957). 1 Swiss franc; 1s. 9d.; 0.30 dollars. [305

Mauritius Sugar Industry Research Institute. Annual Report, 1956. Pp. 92+xx. (Réduit: Mauritius Sugar Research Institute, 1957.) [305

United States Department of Agriculture. Technical Bulletin No. 1156: A Revision of the Genus *Colladonus* (Homoptera, Cicadellidæ). By Mervin W. Nielson. Pp. ii+52+13 plates. (Washington, D.C.: Government Printing Office, 1957.) 25 cents. [305

Meddelanden från Statens Skogsforskningsinstitut, Band 46, 1956. (Reports of the Forest Research Institute of Sweden, Vol. 46.) Pp. 572. (Stockholm: Statens Skogsforskningsinstitut, 1957.) [305

Smithsonian Miscellaneous Collections. Vol. 134, No. 6: Studies by Phase-Contrast Microscopy on Distribution of Patterns of Hemolymph Coagulation in Insects. By Charles Grégoire. Pp. ii+35+1 plate. (Publication 4271.) (Washington, D.C.: Smithsonian Institution, 1957.) [305

Publikationer fra det Danske Meteorologiske Institut. Isforholdene i de Arktiske Have, 1954. (The State of the Ice in the Arctic Seas, 1954.) Prepared by Helge Thomsen and Cmdr. M. V. L. Lorck, R.D.N.R. (Appendix to the Nautical-Meteorological Annual, 1954.) Pp. 33+17 maps and charts. (Charlottenlund: Danske Meteorologiske Institut, 1957.) [305

Metropolitan Life Insurance Company. Statistical Bulletin, Vol. 38 (April 1957): Factors in Perinatal Mortality. Pp. 12. (New York: Metropolitan Life Insurance Company, 1957.) [305

World Meteorological Organization. International Geophysical Year 1957–1958. Meteorological Programme—Lists of Stations. Pp. 108. (Geneva: Secretariat of the World Meteorological Organization, 1957.) 8 Swiss francs. [305

Eighth Annual Report of the Commonwealth Scientific and Industrial Research Organization for the year 1955–56. Pp. 180. (Canberra: Government Printer, 1956.) 10s. 6d. [305

Institute of Marine Research, Djakarta. Marine Research in Indonesia No. 2: The Computation of Oceanic and Meteorological Fields of Motion with Friction Proportional to the Velocity. By Klaus Wyrtki. Surface Salinities in the Strait of Malacca. By Rd. E. Soerjasatmadja. Oceanographic Station List, 1956. Pp. 55. (Djakarta: Institute of Marine Research, 1956.) 1 U.S. dollar. [305

Index and List of Titles, Publications of the Fisheries Research Board of Canada, 1901–1954. Prepared by Yvonne Bishop, Neal M. Carter, Dorothy Gailus, W. E. Ricker, and J. Murray Speirs. Pp. xii+208. (Ottawa: Queen's Printer, 1957.) 75 cents. [305

Imperial College of Tropical Agriculture, Trinidad. Report of the Governing Body and the Principal's Report for 1955–56. Pp. 56. (St. Augustine, Trinidad, and London: Imperial College of Tropical Agriculture, 1957.) [305

Commonwealth Scientific and Industrial Research Organization, Bulletin No. 279: The Mechanical Properties of Australian, New Guinea, and other Timbers. By Alison M. Stewart and N. H. Kloot. Pp. 71. (Melbourne: Commonwealth Scientific and Industrial Research Organization, 1957.) [305

Chicago Natural History Museum. Fieldiana: Geology. Vol. 10, No. 29; The Nature of Shield Abnormalities in the Turtle Shell. By Rainer Zangerl and Ralph G. Johnson. Pp. 341–362. 60 cents. Fieldiana: Zoology. Vol. 34, No. 42: Notes on Amphibians and Reptiles from El Salvador. By A. Stanley Rand. Pp. 505–534. 50 cents. Vol. 39, No. 6: The Subspecies of the Bush Shrike *Lanarius fulleborni* (including *L. poensis*). By Austin L. Rand. Pp. 47–50. 10 cents. Vol. 41, No. 1: Philippine Snails of the Family Endodontidæ. By Alan Solem. Pp. 12. (Chicago, Ill.: Chicago Natural History Museum, 1957.) 40 cents. [305

Editorial and Publishing Offices of "NATURE"
MACMILLAN & CO., LTD.,
ST. MARTIN'S STREET, LONDON, W.C.2.
Telephone Number: Whitehall 8831. Telegrams: Phusis Lesquare London

Annual subscription £7/10/–, payable in advance, postage paid to any part of the world

Advertisements only should be addressed to
T. G. Scott & Son, Ltd., 1 Clement's Inn, London, W.C.2
Telephone Number: Holborn 4743

All rights reserved. Registered as a newspaper at the General Post Office

AHF

ANHYDROUS HYDROFLUORIC ACID

AHF is the most important agent for the production of organic fluorine compounds either by replacement of chlorine atoms or by addition to unsaturated substances. Another important use is as a catalyst in the production of high-octane fuels by alkylation. Other alkylation and acylation reactions are also catalysed by AHF. It is the raw material for producing fluorine and has been used as a solvent medium for certain reactions.

PHYSICAL PROPERTIES

Boiling Point (760 mm.)	19.9°C.
Freezing Point	−83°C.
Specific Gravity (Liquid 0°C)	1.01
Specific Heat (Liquid 0°C)	0.85

The vapour is polymerised to a degree which varies rapidly with temperature and pressure producing a corresponding variation in the heat of vaporisation.

SPECIFICATION

The normal grade of AHF contains at least 99% HF, and impurities to the following limits:–

H_2O	0.5% max.
SO_2	0.25% max.
Si (calc. as SiF_4)	0.25% max.
H_2SO_4	0.01% max.
H_2S	may be present in traces.

Higher grades up to 99.9% HF can be supplied according to need.

CONTAINERS

AHF is transported in steel tank wagons holding from six to eight tons, and in steel cylinders of 6 lb., 50 lb. and 230 lb. capacity.

Advice on materials of construction, handling and first-aid measures may be obtained from

PRODUCTS OF IMPERIAL SMELTING

CONSOLIDATED ZINC CORPORATION (SALES) LTD · 37 DOVER STREET · LONDON · W1

BECK NO. 48

BINOCULAR AND MONOCULAR MICROSCOPE

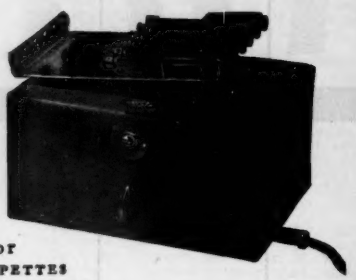
PRE-EMINENT IN EASE OF MANIPULATION & EXCELLENCE OF PERFORMANCE

R & J BECK LTD

69 MORTIMER STREET • LONDON • W1

FOUNDED HAWKSLEY LONDON IN 1869

"CRISTA" PIPETTE SHAKER
with
Interchangeable Heads



For
PIPETTES
KAHN TUBES
BOTTLES

Details on request

HAWKSLEY & SONS LIMITED
17 NEW CAVENDISH ST. LONDON W1
WELBECK 8557

GREEN'S

PURE FILTER PAPERS

Always reliable year after year. Write for our guide to the use of Filter Paper called "N Signposts"

J. BARCHAM GREEN LTD.
MAIDSTONE, ENGLAND

ULTRA-VIOLET CELLS
Variable path-length cells for liquids

INFRA-RED CELLS
Variable path-length cells for liquids
Fixed path-length cells for liquids and gases
Microcells for liquids

PRESS for making KBr and KCl DISKS
as used in I-R and U-V solid state study
Improved and **chromium plated**

HIGH SPEED VIBRATION MILL
ideal for KBr disk technique and other fine and fast grinding. Available for 50 and 60 cycle mains

ROTATING ELECTRODE
(solution excitation) **SPARK UNIT**

Descriptive literature on application

RESEARCH & INDUSTRIAL INSTRUMENTS CO.
30 Langton Road, Brixton, London, S.W.9
RELiance 6171

Printed in Great Britain by FISHER, KNIGHT & CO., LTD., The Gainsborough Press, St. Albans, and published by MACMILLAN & CO., LIMITED, at St. Martin's Street, London, W.C.2, and ST. MARTIN'S PRESS, INC., 103 Park Avenue, New York 17, N.Y., U.S.A.—Saturday, July 13, 1957.